ADOPTION OF CONSERVATION TILLAGE TECHNOLOGIES IN METEMA WOREDA, NORTH GONDAR ZONE, ETHIOPIA.

M.Sc Thesis

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ADOPTION OF CONSERVATION TILLAGE TECHNOLOGIES IN METEMA WOREDA, NORTH GONDAR ZONE, ETHIOPIA.

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By

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As Thesis Research advisor, we here by certify that we have read and evaluated this thesis prepared, under our guidance, by Tigist Petros Woldeselassie, entitled **Adoption of Conservation Tillage Technologies in *Metema Woreda,* North Gondar Zone, Amhara Region**. We recommend that it be submitted as fulfilling the Thesis requirement.

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DEDICATION

This thesis is dedicated to my father **Petros Woldeselassie,** who sacrificed much to bring me up to this level but I lost him on March, 2008.

STATEMENT OF AUTHOR

First, I declare that this thesis is my work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillments of the requirements for an M.Sc degree at the Haramaya University and is deposited at University Library to be made available to borrowers under rules of the Library. I solemnly declare that this thesis is not submitted to any other institution for the award of any academic degree, diploma, or certificate.

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BIOGRAPHY

The author was born in *Gondar Town,* North Gondar Zone of Amhara Region in May, 1975. She completed her elementary and junior secondary school education at *Debreselam Catholic* School and high school at Fasiledes comprehensive and secondary high school. She joined Jimma Junior Agricultural College in September 1991 and graduated with Diploma in General Agriculture in August 1992.

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ABBREVATIONS AND ACRONYMS

BOA	Bureau of Agriculture
BBM	Broad Bed Maker
CIMMYT	International Maize and Wheat Improvement Center
CSA	Central Statistic Authority
CT	Conservation Tillage
DA	Development agent
GDP	Gross Domestic Product
GO	Governmental Organization
GTZ	German Technical
HH	Household head
ILRI	International Livestock Research Institute
IPMS	Improving Productivity and Market Success
Lt	Liters
MOA	Ministry of Agriculture
NGO	Non Governmental Organization
PA	Peasant Association
PRA	Participatory Rural Appraisal
RAAKS	Rapid Appraisal of Agricultural and Knowledge Systems
SD	Standard deviation
SPSS	Statistical Package for Social Science
TLU	Tropical Livestock unit
T&V	Training and Visit
VIF	Variance Inflation Factor
WOARD	Woreda Agricultural and Rural Development

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ADOPTION OF CONSERVATION TILLAGE TECHNOLOGIES IN METEMA WOREDA, NORTH GONDAR ZONE, ETHIOPIA.

ABSTRACT

As in most parts of Ethiopia, soil degradation has posed a serious challenge to the productivity of agriculture in the high rainfall areas of Metema Woreda of the Amhara Regional State. Crop productivity in the Metema area is further constrained by weeds which are favored by the high rainfall and temperature characterizing the area. Current weed control practices involving repeated plowings (often up to four times) and hand pulling imposes not only high production costs but also aggravated soil degradation affecting the sustainability of agricultural production. In an attempt to improve agricultural productivity and reduce soil degradation, conservation tillage (CT) technology involving zero tillage with or without pre-emergence herbicide was introduced in Metema woreda since 2005. This study, therefore, explored the CT adoption decision behavior of smallholder farmers in the Metema woreda of the Amhara Regional State. A multistage sampling procedure was used to identify peasant associations and then households. In the first stage, the PAs were stratified into two groups based on the degree of conservation tillage extension efforts. The selected PAs were further stratified into two based on distance to the woreda capital. Then, two PAs form early exposed and two PAs from the late exposed groups were selected. Finally, a total of 130 household heads were selected randomly using probability proportional to size from the identified PAs. Both qualitative and quantitative data were collected from the sampled households. While the qualitative data were generated from focus group discussions and key informants using check lists, quantitative data were collected from sampled households using structured interview schedule. The structured interview schedule was pre-tested, revised and then administered by well-trained enumerators recruited from the study area. Descriptive statistics such as mean, standard deviations and frequencies were used to summarize the data while binary logit model were fitted to identify the most important variables influencing CT adoption decision behavior of sample households. Study results revealed that 54.1% of sample farmers adopted CT during the study year. Friends, neighbors and development agents were found to be the major sources of knowledge suggesting farmer to farmer communication plays a crucial role in knowledge transfer in the study area. Results of the econometric (binary logit) model indicated that farming experience of household heads, land holding, social participation, frequency of contact with extension agent, and frequency of participation in field days were found to have positive and significant influence on adoption of conservation tillage technology further signifying the importance of appropriate communication strategies in technology adoption. Generally, the result of this study indicates that adoption of conservation tillage technology is a result of an interplay of several factors, which should be given due attention in the generation and transfer of agricultural technologies including conservation tillage.

1. INTRODUCTION

1.1 Background and Justification

Agriculture is the mainstay of the Ethiopian economy and the people at large. It contributes 50% of gross domestic production (GDP), employs 85% of the population and the main income-generating sector for the majority of the rural population. It also serves as the main source of food and generates 90% of the foreign exchange earnings. It provides raw materials for more than 70% of the country's industry (Getahun, 2004).Despite its importance in the livelihood of the people and its potential, the sector has remained at subsistence level. In general, low productivity characterizes Ethiopian agriculture. The poor performance in food production coupled with rapid population growth of 3.19% during 1980-1990 aggravated the problem of household food security and per capita food production. In addition , climate change, reduced soil fertility, recurrent and prolonged drought, environmental degradation, reliance on traditional agricultural practices, lack of inadequate financial services and human capital, weak agricultural markets and poor infrastructure are believed to have responsible for the low productivity of the agricultural sector (Berhanu,2002).

In an attempt to increase agricultural productivity and improved food security at both national and household level, efforts have been underway to generate and disseminate improved agricultural technologies among smallholder farmers. Conservation Tillage (CT) is one of the technologies promoted in Ethiopia for enhancing sustainable agriculture. Conservation tillage includes several practices such as no or minimum tilling, soil cover, crop rotations, organic amendment, etc., that permit the management of soil for agrarian uses, altering its composition, structure and natural biodiversity as little as possible and protecting it from erosion and degradation. It has both environmental and socioeconomic benefits. Conservation tillage is widely adopted in North and South American countries such as Brazil, Argentina, Canada, and USA (Yadete, 2007). Especially, these days, its adoption is growing at fastest rate throughout the world as its benefit is recognized over years.

In Sub Saharan African (SSA) countries in general, and Ethiopia in particular, the use of CT is reported to be low. However, in some countries such as South Africa, Zimbabwe and Zambia, CT is well established under large-scale commercial farming. In Ethiopia, despite the fact that soil degradation is severe, CT is not widely practiced by farmers. Recently, however, recognizing its predetermined benefit, government and non government organizations (NGOs) are widely promoting its use among smallholder farmers throughout the country (Yadete, 2007).

Among the areas in Ethiopia, conservation tillage which includes the use of non-selective herbicide and zero tillage are being promoted in Metema Woreda of the Amahara Region since 2005. The technology is appropriate in places like Metema where the climatic factors aggravate rapid weed growth, shortage of manpower for hand weeding and shortage of draught animal for ploughing. The wise use of the technology reduces the work load of women and the demand for employed labor.

1.2 Statement of the problem

The adoption of agricultural innovation in developing countries including Ethiopia has attracted considerable attention because it can provide the basis for increasing production and income. However, evidence indicates that most of the adoption studies so far conducted in the country largely focused on improved crop varieties and associated agronomic practices such as soil fertility management and crop protection practices. The attention provided to the adoption of conservation tillage to date is minimal. Even then, the rate of adoption of modern agricultural technologies in the country is reportedly very low (Kebede *et al.*, 1990).

In the high rainfall areas such as Metema, weed growth is very fast and colonize crop fields within a short period of time reducing crop yields substantially (personal communication). Farmers in Metema use various practices to combat weed infestation including repeated ploughing, hand weeding and herbicide use (in sorghum). However, many farmers complained that weed control practices which involves repeated ploughing often employing rented oxen and several hand weeding are costly impinging on the profitability of crop farming.

Metema has adequate potential for rearing draught animal such as cattle but, farmers' faced difficulties to keep their livestock safely due to aggravated oxen theft for the Sudan market. Consequently, many small scale farmers depend on rented oxen that moved from the highland areas seasonally.

In attempt to reduce some of the identified problems, Improving Productivity and Market Success of Ethiopian small holder farmers' project introduced conservation tillage involving zero tillage and weed control using a pre-emergence herbicide in the Metema area since 2005. The project organized demonstration activities, trained woreda experts, development agents and farmers to facilitate adoption of CT among farmers. Input suppliers were also organized to facilitate timely supply of the required inputs at reasonable cost. The adoption of CT and the factors that determine use of CT, however, have not been assessed. This study, therefore, attempts to explore the following research questions:

- What is the status of adoption of conservation tillage technology in the study area?
- What are the relative importances of the various factors associated with adoption of conservation tillage technology?
- What is the role of farmer-to-farmer knowledge sharing in the diffusion process of this technology in the study area?

1.3 Objective of the Study

The general objective of the study is to assess the rate of adoption and factors that influence adoption of conservation tillage technology in Metema woreda.

Specific tasks pursued under these main objectives include:

- to assess the rate of adoption of conservation tillage technology by farmers;
- to explore the contribution of farmer-to-farmer knowledge/material technology sharing for adoption and diffusion; and
- to determine the relative importance of the various factors influencing adoption of conservation tillage technologies in the study areas.

1.4 Significance of the study

Comprehensive understanding of farmers' adoption of conservation tillage technologies is crucial in designing future research and development strategies. This study will help policy makers to develop evidence based future research, extension, and development programs aimed at benefiting smallholder farmers. Policy makers will benefit from the research output, since they require micro-level information to formulate policies and strategies so that their effort would be appropriate in meeting smallholder farmers' need in particular and to bring change in agricultural sector, in general. Also this research result will benefit development planners, other researchers and ultimately the farmers. In addition to this, this piece of work tries to identify determinants of adoption of conservation tillage technology by farmers. Therefore, the study will generate information on diverse set of issues related to adoption of conservation tillage technology in Metema woreda.

1.5 Scope and limitation of the study

This adoption study on conservation tillage technology in Metema woreda is the first of its kind. Therefore, its scope is limited in terms of coverage and depth owing to financial and time resources. The study was carried out by surveying a sample of 130 farm households from four peasant associations (PAs). Nevertheless, the result of this study can also be used as a reference for other similar areas adoption.

1.6 Organization of the Thesis

The rest of this thesis is organized into five chapters. Chapter two reviews the relevant literature that includes definition of important terms, concepts of adoption, limitation of adoption and diffusion, empirical studies on factors affecting adoption and analytical frameworks employed in adoption studies. In chapter three, brief description of the study area and research methodology are presented. Survey results are discussed in chapter four. Finally chapter five presents the summary, conclusions and recommendations of the study.

2. LITERATURE REVIEW

2.1 The definition and concept of conservation tillage

Different scholars define conservation tillage in different ways. According to world encyclopedia, conservation tillage means:

- No-till farming (sometimes called zero tillage) is a way of growing crops from year to year without disturbing the soil through tillage.
- An agricultural system using tillage techniques designed to reduce soil erosion and overland flow. Most conservation tillage techniques involve less manipulation of the soil than conventional techniques, leaving more plant matter on the soil surface.

Tillage has long been an essential component of traditional agricultural systems. Broadly defined, tillage is the mechanical manipulation of the soil and plant residues to prepare a seedbed for crop planting.

Conventional tillage is the traditional method of farming in which soil is prepared for planting by completely inverting it with a mould board plow. Subsequent working of the soil with other implements is usually performed to smoothen the soil surface. Bare soil is exposed to the weather for some varying length of time depending on soil and climatic conditions.

Conservation tillage is a term used to describe a number of technologies that are utilized in agriculture to conserve water and soil. Emphasis is placed on decreasing the amount of soil disturbance and managing crop residues to protect the soil surface. Conservation tillage practices include, amongst others, strip tillage, cover cropping, contour farming, zero or chemical tillage, mulch tillage, and reduced tillage, with the ultimate being low disturbance no-till or direct seeding (Unger, 1984).

A transition from moldboard plow to various forms of conservation tillage began with the development of 2,4-D after World War II. No-till is presently practiced on about 95 million hectares globally. No-till technologies are very effective in minimizing soil and crop residue disturbance, controlling soil evaporation, minimizing erosion losses, sequestering carbon in soil and reducing energy needs (Reicosky and Hanson, 2007).

2.2 Conservation tillage in Ethiopia

Farmers in Ethiopia tend to plough frequently, between three and four times before planting to destroy weeds and prepare smooth seedbeds for good germination and plant growth. However, this approach also pulverizes the soil and destroys its physical structure: with each ploughing, the top soil and soil organic matter are exposed to erosion by rain and wind. This causes soil fertility to decline and reduces the water-holding capacity of the soil, rendering it unproductive over time. Furthermore, it allows soil moisture to evaporate, making crops more vulnerable to moisture stress later in the season and reducing yields. In order to arrest the loss of the topsoil, build organic matter, improve soil structure, and enhance water and nutrient capacity, the traditional system must be exchanged for a conservation/ minimum tillage approach (SG 2000, 2007).

The primary effect of conservation tillage (CT) is to reduce soil erosion and conserve soil moisture. In conservation tillage, the only disturbance to the soil is to dig a small hole or narrow trench to apply fertilizer and plant seeds. Crop residues are left on the farm plots after harvest as long as possible, because they protect the soil and the crop against erosion and water runoff, reduce soil moisture evaporation and inhibit weed germination. Conventional weeding is replaced by a non-selective glyphosate herbicide called Roundup, which is applied to actively growing weeds seven to ten days before planting. This creates good conditions for seed germination, plant growth and effective weed control, as the dried up weeds become part of the crop residue. For long-term sustainability, crop rotations are still needed to minimize the build-up of pests or diseases and optimize plant nutrient use at different soil depths through synergy between different crop types (SG 2000, 2007).

2.3 Concepts of adoption

2.3.1 Definition of adoption

Organization for Economic Cooperation and Development (1999), defined an innovation as any knowledge (new or existing) introduced into and used in an economically or socially relevant process.

The adoption of an innovation within a social system takes place through its adoption by individuals or groups. According to Feder, et *al*. (1985), adoption may be defined as the integration of an innovation into farmers' normal farming activities over an extended period of time. Adoption, however, is not a permanent behavior. Dasgupta (1989) noted that an individual may decide to discontinue the use of an innovation for a variety of personal, institutional, and social reasons one of which might be the availability of another practice that is better in satisfying farmers' needs.

Feder, et *al*. (1985), classified adoption as an individual (farm level) adoption and aggregate adoption. Adoption at the individual farmers' level is defined as the degree of use of new technology in long run equilibrium when the farmer has full information about the new technology and it's potential. In the context of aggregate adoption behavior, diffusion is defined as the spread of new technology within a region. This implies that aggregate adoption is measured by the aggregate level of specific new technology with a given geographical area or within the given population.

2.3.2 Adoption decision process

According to Rogers (1983), the innovation decision process is the process through which an individual or other decision making unit passes from first knowledge of an innovation, to forming an attitude toward the innovation, to decision to adopt or reject, to implementation of the decision, and to confirmation of this decision. This process consists of a series of actions

and choices over time through which an individual or an organization evaluates a new idea and decides whether to incorporate the new idea in to ongoing practices. An individual's decision about innovation is not an instantaneous act, rather it is a process. Based on this, the innovation decision process conceptualization consists of five stages:

i. Knowledge occurs when an individual (or other decision making unit) is exposed to the innovation's existence and gains some understanding of how it functions.

ii. Persuasion occurs when an individual (or other decision making unit) forms a favorable or unfavorable attitude towards the innovation.

iii. Decision occurs when an individual (or other decision making unit) engages in activities that lead to a choice to adopt or reject the innovation

iv. Implementation occur when an individual (or other decision making unit) puts the decision to adopt or reject into practice

v. Confirmation occurs when an individual (or other decision making unit) seeks reinforcement of an innovation decision already made, but he/she may reverse this previous decision if exposed to conflicting messages about the innovation.

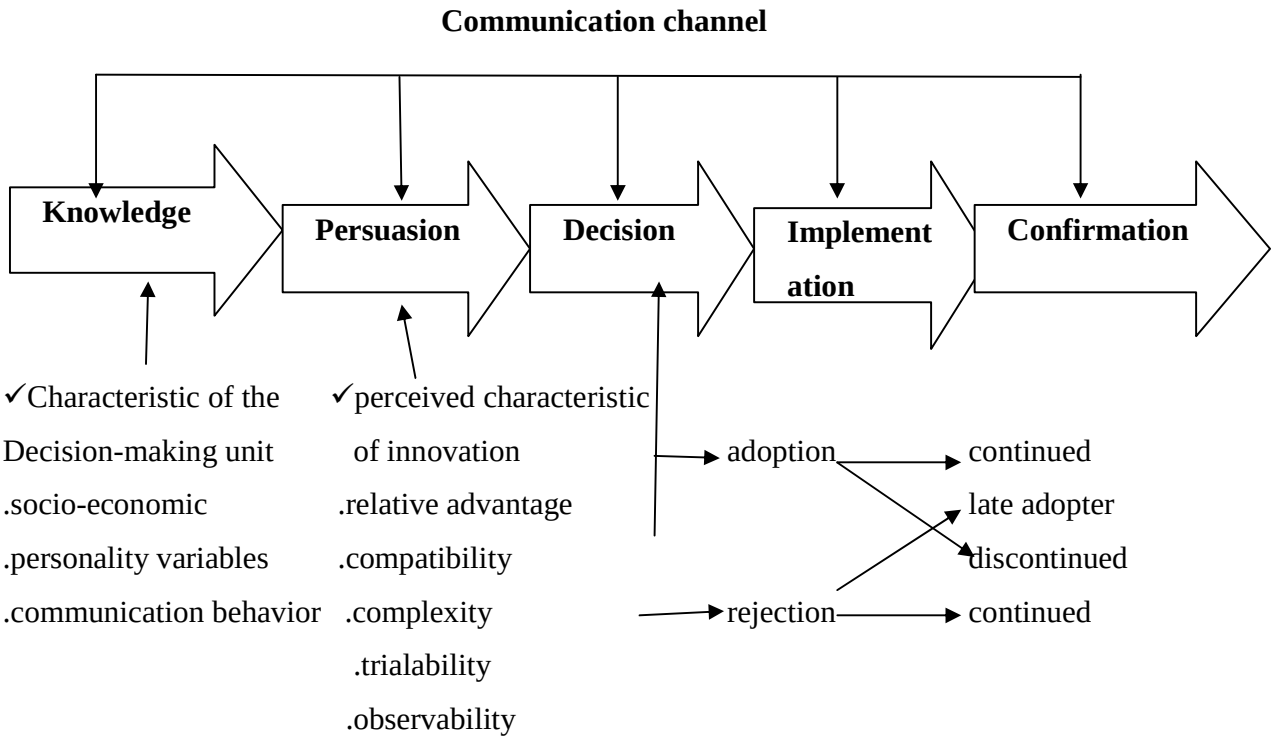

Figure 1: The innovation decision process (Rogers, 1983).

2.3.3 Diffusion of conservation tillage practice

According to Rogers (1962) the diffusion of an innovation is the process by which an innovation is communicated through certain channels over time among the members of a social system. People do not just welcome every innovation that is put in front of them. Every person reacts differently in the ways that he/she hears about, understand, and finally accept or do not accept an innovation.

There are four main elements to the diffusion of innovations: (1) the innovation, (2) its communication, (3) in a social system, (4) over a period of time.

- Innovation: any item, thought, or process that is viewed to be new by the consumer.
- Communication: the process of the new idea traveling from one person to another or from one channel to the individual.

- Social System: the group of individuals that together complete a specific goal.
- Time: how long it takes for the group to adopt an innovation as well as the rate of adoption for individual.

The diffusion process is not a mathematical equation or a chemical reaction but rather a natural progression of peoples' attitudes, opinions, and feelings towards accepting a new idea. All four elements have many different factors that affect the outcome of the process as well as act intimately to affect each other (Rogers, 1962).

2.3 Knowledge Network

Knowledge can be understood as both information and skills that are acquired through individual experience and trial and error, within an organization or a learning community, or from outsiders adapting it to local contexts. Knowledge that rural and farming communities are typically interested in includes cultural management practices; new agricultural technologies, market information on inputs and sales and government policies etc (Hartwich *et al.,* 2007).

According to Paul (1997), knowledge is not simply that is possessed and accumulated, it emerges out of process of social interaction and should be looked at in terms of social relationships. What people know and how they go about learning is intrinsically woven into their life as social beings. Knowledge emerges as a result of social efforts to come to grips with the demands, the social and physical environments in which individuals and groups are immersed. Knowledge includes the ideas, concepts routines and skills people acquire over time to support their livelihood.

Since knowledge is dynamic, it is constantly produced and reproduced, shaped and reshaped and yields many types of knowledge, differentiated within and between localities (Mango, 2002). According to Joshi *et al.,* (2004) knowledge continuously evolves as farmers learn both by evaluating the outcomes of previous actions and by observing the environment. This means that knowledge that enters a locality is not simply internalized, but becomes transformed by various actors to suit their circumstances.

Farmers use many different sources including their own, to obtain knowledge and information they need to manage their farms and that new knowledge is develop not only by research institutes but also by many different actors (Ray, 1999).

Social and informational networks do exist within the farming community; they exert a significant influence on farm-level decision making; and such networks affect different decision domains in different ways.

Small-scale producers often rely on informal mechanisms of information exchange and knowledge sharing to address agricultural problems and challenges. Given the limited scope of formal extension programs, informal exchange is often the primary source of information about new technologies in sub-Saharan Africa. The increasing role of informal mechanisms for information sharing has been recognized in the literature through farmer-to-farmer models of agricultural development (Eveleens, *et al*., 1996).

Information exchange in social networks also provides important economic benefits. For example, dense networks with the dominance of strong ties enable a 'thick' information exchange that makes new knowledge quickly available for all actors in the network. On the other hand, loose networks composed by a large number of weak ties give access to a large amount & novelty of information that might, however be less detailed and strategic than provided by the strong ties (Agapitova, 2005).

2.4 Empirical Studies on Factors Affecting Adoption of Technologies

A number of empirical studies have been conducted by different people and institutions on the adoption and diffusion of agricultural innovations both outside and inside Ethiopia. But, the studies are mainly conducted around major cereals other crops and practices and due to this fact the studies conducted on the area of conservation tillage technologies are very limited. As a result of this, the review mainly included such studies conducted in different contexts. For ease of clarity the variables so far identified as having relationship with adoption are categorized as

personal and demographic variables, economic factors, socio-psychological related factors, and extension/communication factors.

2.4.1. Personal and demographic variables

Household's personal and demographic variables are among the most common household characteristics, which are mostly associated with farmers' adoption behavior. From this category of variables, education, experience in farming and age were reviewed in this study.

Education is associated with adoption because it is believed to increase farmers' ability to obtain, and analyze information that helps him/her to make appropriate decision. Similarly, Bekele, et *al*.(2000) and Tesfaye and Alemu (2001) indicated positive relationship between education and adoption Teferi (2003) also indicated that education, enhances the adoption of fertilizer use positively. Contrary to this, a study conducted by Asnake,et *al.* (2005) in Ethiopia showed that education had no significant effect on the adoption of improved chickpea varieties.

Several studies (researches) in adoption of soil conservation are conducted in different parts of Ethiopia. For example, research by Yitayal (2004) in Dedo district of Jimma Zone indicated that significantly affecting use of soil conservation measures includes area of cultivated land to labor ratio, age of household head, education level of household head, distance of the farm from home, slope of the farm plot and availability of extension services. In this study perception to soil erosion problem and land security had no statistical support for implementation of soil water conservation practices.

Farming experience is another important household related variable that has relationship with adoption. Longer farming experience implies accumulated farming knowledge and skill, which has contribution for adoption. Many studies supported this argument. For instance, Kidane (2001), Melaku (2005) and Yishak (2005) have reported farming experience positive and significant relation with adoption. In the same line, Mahdi (2005) found the mean farming experience difference of adopters and the non-adopters is statistically significant. In contrary, Ebrahim (2006) found that farming experience had negative relationship with overall dairy

adoption. However, Rahmeto (2007) reported that farming experience had no statistically significant relationship with adoption.

2.4.2. Economic variables

Socio-economic variables influence household's adoption decision of agricultural technologies. In this study, economic variables such as total land holding, labor availability, livestock possession, herbicide price, and participation in non-farm, participation in off-farm and access to credit are assumed to play a great role in determining the willingness and ability to invest in adoption of agricultural technologies.

Land related variables influence farmers' adoption behavior, as land holding is an important unit where agricultural activities take place. Concerning land holding, different studies reported its effect positively. For example, a study carried out by Tesfaye and Alemu (2001) reported that farm size contributed positively in farmers' adoption of improved wheat varieties. Asnake *et al.* (2005) conducted a study on adoption of improved chickpea varieties in Ethiopia and found that farm size was positively related to the adoption of improved varieties. Similarly, Mulugeta (2000), Million and Belay (2004), Yishak (2005) and Taha (2007) reported positive relationship of farm size with adoption.

Livestock holding is an important indicator of household's wealth position. Livestock is also an important income source, which enables farmers to invest on adoption of improved agricultural technologies. In most cases, livestock holding has positive contribution to household's adoption of agricultural technologies. Many adoption studies have reported positive effect of livestock holding on adoption. To mention some Degnet and Belay (2001), Kidane (2001), Birhanu (2002), Techane (2002), Endrias (2003) and Taha (2007) have found that livestock holding has positive influence on adoption of improved agricultural technologies.

A study conducted by Kidane (2001) on factors influencing the adoption of new maize varieties revealed that shortage of labor affected the adoption of the new maize varieties. On the contrary, Yishak (2005) and Abrhalay (2006) reported that labor availability did not affect

adoption of improved Maize and Integrated Striga Management technologies, respectively.

The study by Roush (2001), in KwaZulu-Natal indicate that farmers adopting conservation tillage technology have seen their maize yields rapidly increased from less than two tons per hectare up to more than seven tons per hectare. There were about a dozen farmers who have harvested ten tons per hectare, with the record harvest being 11.4 tons per hectare, according to the author.

Apart from the advantage of improved yields and the use of modern technology, farmers are seeing the benefits of improved water conservation and soil structure, which in turn is greatly reducing soil erosion. Land preparation takes considerably less time under a no-till system and the labor requirements are also reduced per-unit area. This allows for increased productivity elsewhere on the farm (Roush, 2001).

The other economic variable that farmers need to get to improve production and productivity is credit service (credit utilization). Capital and risk constraints are key factors that limit the adoption of high value crops by small scale farmers. In line with this, study conducted by different authors such as Mekonnen (2007), Minyahel (2007) and Taha (2007) also found that the use of credit had positive and significant influence on adoption and intensity of adoption of the technologies. Similarly, Getahun (2004), Million and Belay (2004), Mahdi (2005), Ebrahim (2006), kebede (2006) and Tesfaye (2006) also found a similar results.

Concerning non- farm income, many adoption studies have reported positive effect of non-farm activities on adoption. These include Mesfin (2005) who indicated that non-farm income is found to influence adoption of Triticale positively.

In addition, Ebrahim (2006) in his study found that involvement in non-farm activities had positive and significant correlation with adoption. Similarly Taha (2007) also found that participation in non-farm activities have positive and significant influence on adoption and package.

2.4.3. Socio-psychological variables

Socio-psychological variables also influence household's adoption decision of agricultural technologies. In this study, socio- psychological variables were social participation, perception of technology, information seeking behavior, and cosmopoliteness. Concerning social participation, different studies reported its effect in different ways. For example, Ban and Hawkins (1996) indicated that people who are quick to adopt an innovation may be characterized by having active participation in many organizations. Moreover, Haji (2003) also found that social participation contributed positive and significant influence on the adoption of cross-bred cows and Ebrahim (2006) social participation contributed positively to the adoption of diary technologies. Similarly, Dereje (2006) and Rahmeto (2007) reported that social participation had significant and positive relationship with adoption.

Cosmopoliteness is the degree of contact a farmer has with external situations of the social system. This is assumed to influence the access to information on improved farming practices as compared to other members of the group and influence adoption positively. However, Mekonnen (2007) found that cosmopoliteness have negative and significant influence on adoption of decision process.

2.4.4. Extension/communication variables

Household's communication factors are one category of the variables which are mostly associated with farmers' adoption behavior. From this category of variables, contact with extension agent, attendance in extension events, mass media exposure and frequency of contact with extension agents were selected as variables in this study.

Extension provides farmers with information related to agricultural technologies. The relationship between farmers' access to extension services and adoption has been repeatedly reported as positive and significant by many authors. For instance, Haji (2003), Teferi (2003) and Abrhaley (2006) had shown that extension contact affect adoption of new technologies positively and significantly. Similarly, Kebede (2006) and Mekonen (2007) found that a

positive and significant relation between extension contact and adoption of maize verities and Integrated Striga Management, respectively.

Regarding frequency of contact with extension agent, different studies reported positive and significant relation with adoption. Degnet and Belay (2001) reported that, frequency of contact with extension workers positively and significantly affected farmers' adoption decision. Similarly, studies conducted by Kidane (2001), Girmachew (2005), Abrhaley (2006) and Rahmeto (2007) which shown that frequency of contact with extension agent positively and significantly contributed to adoption.

Another communication variable is attendance in extension events like involvement in demonstration, training and participation on field days. They are also crucial in improving farmers' experience, building capacity and developing confidence on the advantages of improved agricultural technologies.

Tesfaye and Alemu (2001) reported that participation in on-farm demonstration and attendance of training contributed positively to farmers' adoption decision. In the same line, Yishak (2005) in his study of determinants of adoption of improved maize technology found that farmers' participation in demonstration had positive and significant relationship with adoption. Similarly, Abrhaley (2006) revealed that farmers' experience in on farm trial has influenced adoption and intensity of use of Integrated Striga Management technology positively and significantly. Moreover, Minyahel (2007) and Rahmeto (2007) found that participation in extension events had positive and significant relationship with adoption.

Mass media exposure is also one of the communication variables. The role of information in decision-making process is to reduce risks and uncertainties to enable farm households to make right decision on adoption of improved agricultural technologies.

Mass media play the greatest role in provision of information in shortest possible time over large area of coverage. However, as compared to other communication channels, its effect on behavioral change is weak as it is limited to awareness creation than skill development. Many

studies reported the positive and significant relationship of mass media with adoption of agricultural technologies. In line with this, Yishak (2005) in his study indicated that ownership of radio had positive influence on adoption of improved maize technologies. Similarly, Ebrahim (2006) also found the same influence.

2.5 Conceptual Framework of the Study

Several literatures, practical experiences and observations of the reality have been showed that one factor may enhance adoption of one technology in one area at one time and may hinder it in another situation, area and time. Therefore, it is difficult to develop a one and unified adoption model in technology adoption process because of the socio- economic and ecological variations of the different sites, and the various natures of the determinant factors.

The conceptual framework of this study is based on the assumption that a number of influences on adoption of conservation tillage technology namely, personal and demographic, extension or communication, economic and socio-physiological variables. The conceptual framework of this study was developed based on the theoretical model of adoption and diffusion discussed in the previous sections. As clearly illustrated in the following diagram, the two categories of variables are explanatory and dependent variables. Hence, the conceptual framework presented in Fig 2 shows the most importance variables expected to influence the adoption of conservation tillage technology in the study area, Metema woreda.

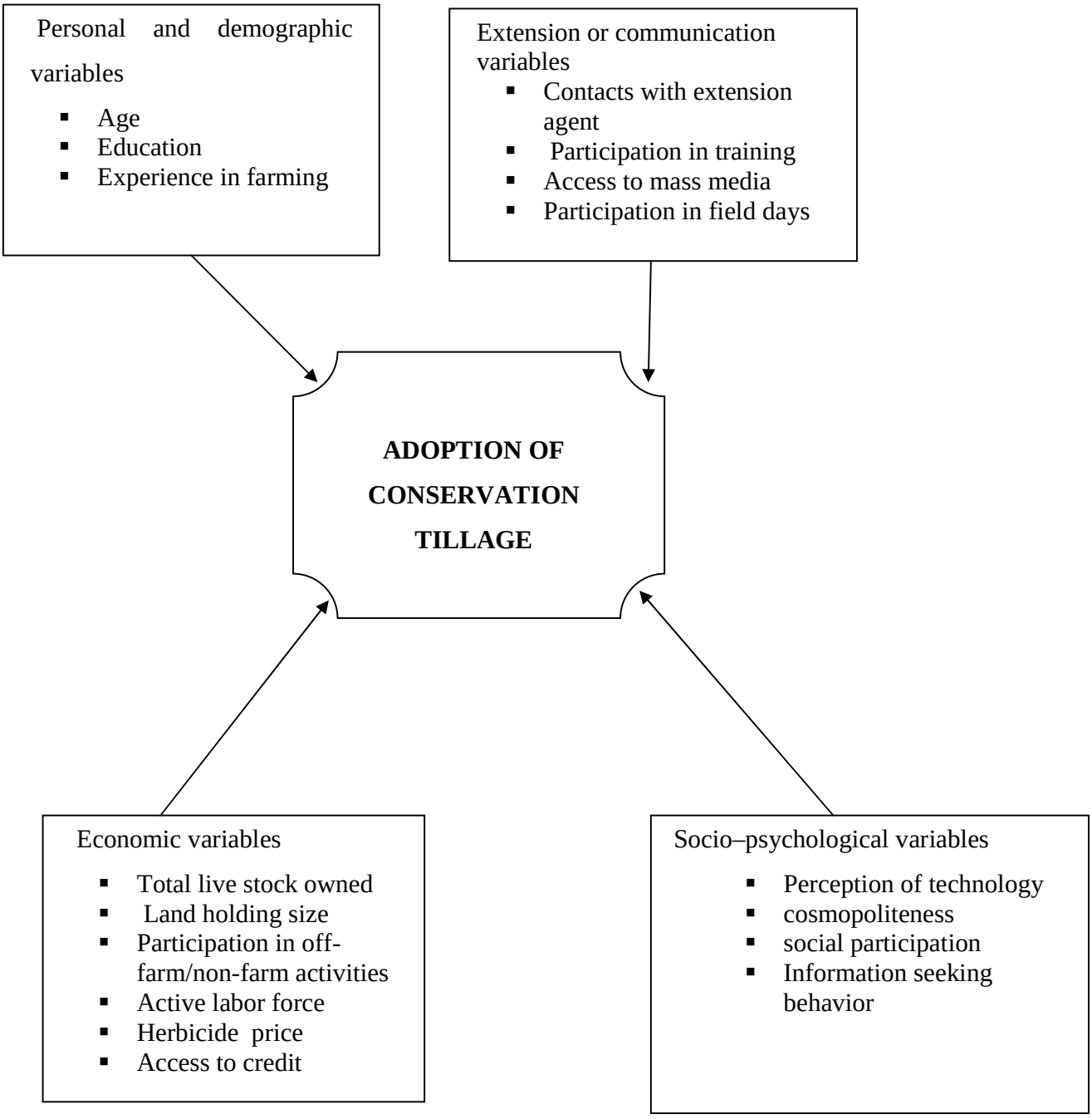

Figure 2. Conceptual Framework of the Study (Adapted from Shiferaw and Holden, 1998).

3. RESEARCH METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location

The study was conducted in Metema woreda of the Amhara National Regional State (ANRS). Metema is located at about 900 km Northwest of Addis Ababa and about 180 km West of Gondar town. Metema is one of the West most Woredas of the Amhara Regional State (Figure 3). The woreda has an international boundary of more than 60 km with Sudan. Metema is found North of Quarra and Alefa, West of Chilga, South of Tach- Arma Choho woredas and East of Sudan border (IPMS, 2005).

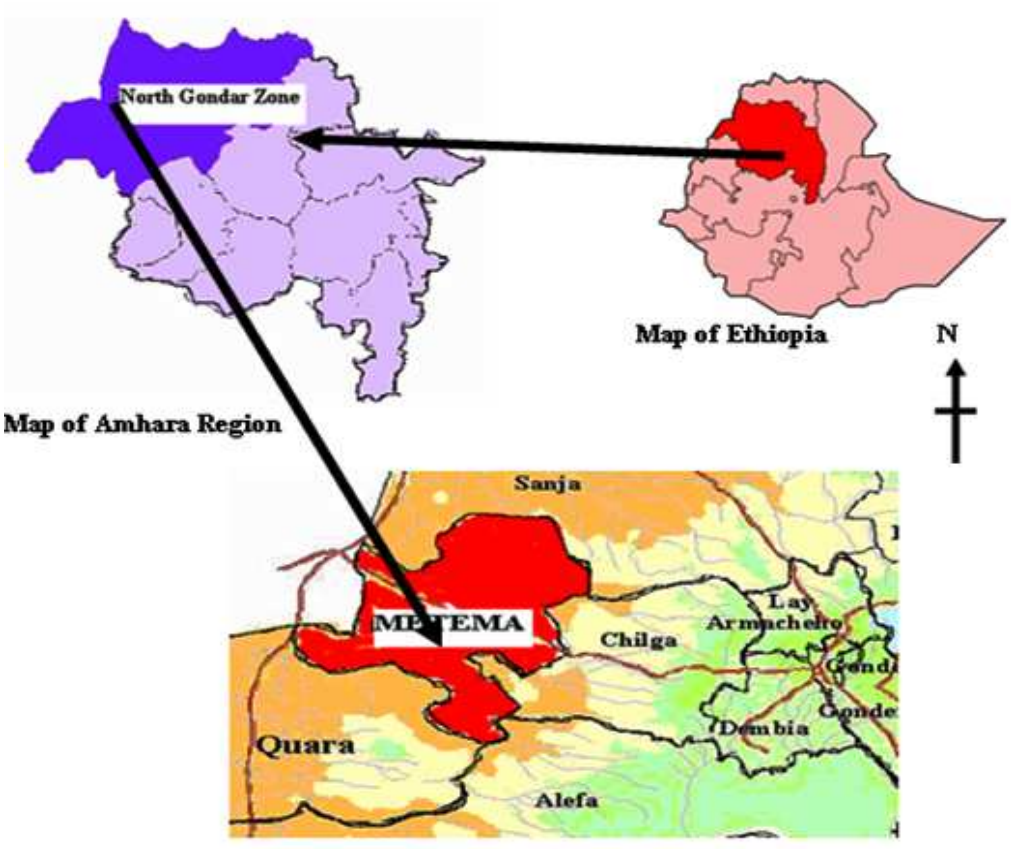

Figure 3**:** Location of the Study Area Source: (IPMS, 2005).

3.1.2. Climate, vegetation and soil condition

The altitude of Metema ranges from 550 to1608 m.a.s.l. The daily maximum temperature becomes very high during the months of March to May, during which the temperature can reach as high as 43^{o}C. The mean annual temperature is about 31 ^{o}C (ILRI, 2005).

Mean annual rainfall of Metema area ranges from about 850 to around 1100 mm, and it receives a unimodal rainfall (ILRI, 2005). The rainy months extend from June to the end of September. However, most of the rainfall is received during the months of July and August, during which the rainfall is erratic. According to ILRI (2005), the natural vegetation of Metema is predominantly composed of different *acacia* species with a lot of *hyparrhenia* grass under grown. Metema is one of the Woredas, where gum and incense are collected. The main species for incense production is *Boswellia papyrifera*, while *Acacia seyal* and *A. polyacantha* are used for gum production.

The soil in the area is predominantly black with vertic properties. Due to this reason, the soil in most areas is observed with excessive cracks, which could be as deep as 0.75 m in some places during the dry season. There are about 9 types of soil in the area, among which Haplic Luvisols prevail in about a quarter of the district and Vertisols or soils with vertic properties exist in about 22% of the districts land area. On the other hand, Humic Nitosols account in about 6%. Seasonal water logging, especially during the months of heavy rainfall is so high, which needs the use of broad bed makers (BBM) to drain the excess over- flow and use the land for crop cultivation or grazing purpose(ILRI, 2005).

3.1.3. Human demography

According to CSA (2005), there are about 76,084 rural and 17,468 urban populations of which 41,202 were male and 34,882 were females in rural area. In the urban areas, 9,108 and 8,360 were male and female, respectively. The original residents of the area were Gumuz. Until

recently, they have practiced slash and burning and hunting wild animals. They have also been engaged in making household furniture like chair, bed, pot and others. When the area became gradually populated, the natives were dominated by the new settlers. The original settlers (Gumuz) are now found only in three peasant associations, the Kumer Aftit, Tumet and Shinfa. The total number of the indigenous people is around 500 (ILRI, 2005). Hence, much of the area is recently occupied by settlers from the highland part of the region. According to WoARD (2009), in the years of 2003, 2004 and 2005 during which new settlement programs occurred, 12,777, 4,124 and 16,258 new settlers were settled in the district, respectively. This shows that there is an aggregate of 33159 settlers during the three years and the trend is increasing.

3.1.4. Farming system

The agricultural production system in the study area is crop-livestock mixed. The crop-livestock mixed production system is the predominant system and exists in all over the district throughout the year. Crop production is the main agricultural activity for the livelihood of the smallholder farmer in the study area. The major crops grown include sorghum, rice, cotton, sesame, haricot bean, soybean and new emerging crops like teff, chickpeas and banana.

Livestock production is an integral part of the land use system. Production of cattle (as draught power, milk and meat), shoat (income and meat), donkey and camel (as *Karoo* and transport) and poultry was commonly practiced. WoARD (2009) report shows that the livestock population of the district is composed of 136,910 cattle, 32,024 goats, 1,686 sheep, 7,164 male donkeys, 7,127 poultry, 400 camels and 23,789 beehives. Cattle in the district are exported both legally and illegally, through smuggling to Sudan, while goats and other animals are mainly sold in local markets.

According to ILRI (2005), Metema district was categorized into cotton, sorghum and rice/ livestock based/ and sesame, cotton, and sorghum/ livestock based farming systems based on the type of crop production. The livestock production system is similar in both farming systems.

Therefore, there are two types of farming systems used in the study district namely cotton based farming system and sesame based farming systems. Each has its own characteristic features regarding to the crop production nature.

According to ILRI (2005), 4 out of 18 peasant associations (PAs) belong to cotton farming system. They are Maka, Awlala, Genda Wuha and Kemechela. They are found in the Northeast parts of the district. The PAs are relatively colder in temperature, have higher altitude and rainfall. Farmers in the PAs practice slightly early planting of crops. The soil is black and water logging is a problem. The majority of the soils in this farming system have vertic property. Many of the areas are also flat. The PAs in this farming system have different features in terms of suitability for crop production and amount of rainfall received. The majority of the soils are only suitable for growing cotton and rice. The PAs predominantly grow cotton and sesame in little amount. Cotton is grown in wide areas while sorghum and sesame are planted on very smaller areas.

Fourteen PAs belong to sesame based farming system. In order of importance, sesame, cotton and sorghum are the major crops produced in this farming system. A farmer could grow any one of these crops as the environmental conditions are equally suitable for these crops. The choice is set by the farmer upon observation of the season, high or low rainfall, and possible market prices. The altitude and rainfall in this farming system is less than the cotton based farming system. The altitude range for this farming system is between 550 and 700 masl (ILRI, 2005). Farmers and agriculturists believe that the underground water table is high. In some places, sufficient amount of water could be obtained at less than 10m deep. Besides, three rivers are found in this farming system. These rivers make the area more potential for crop and livestock development. This farming system also has extensive grazing areas. There is also a place where the natural plantations for gum and incense are located.

3.2 Sample and Sampling technique

3.2.1 Sampling procedure

The study adopted a multi-stage sampling technique to select the sample PAs and household farmers. Metema woreda was selected purposively since it is one of IPMS project intervention areas. In the first stage, the PAs were stratified into two groups based on the degree of conservation tillage extension efforts (first exposed PAs in 2005 and late exposed PAs in 2007). The selected PAs were further stratified into two based on distance to the woreda capital. Then, two PAs form early exposed and two PAs from the late exposed groups were selected randomly (one from far and one from near woreda capital in each stratum). Finally, a total of 130 household heads were selected randomly using probability proportional to size from the identified PAs. In this study, sample size was determined by taking different factors such as research cost, time, human resource, availability of transport facility, and other physical resource accessibilities. By taking these factors into account, it was fixed to cover four Peasant Associations out of 18 PAs. Finally, a total of 130 household heads were selected randomly using probability proportional to size from the identified PAs.The number of sample respondents in each rural PA is presented in Table 1 below.

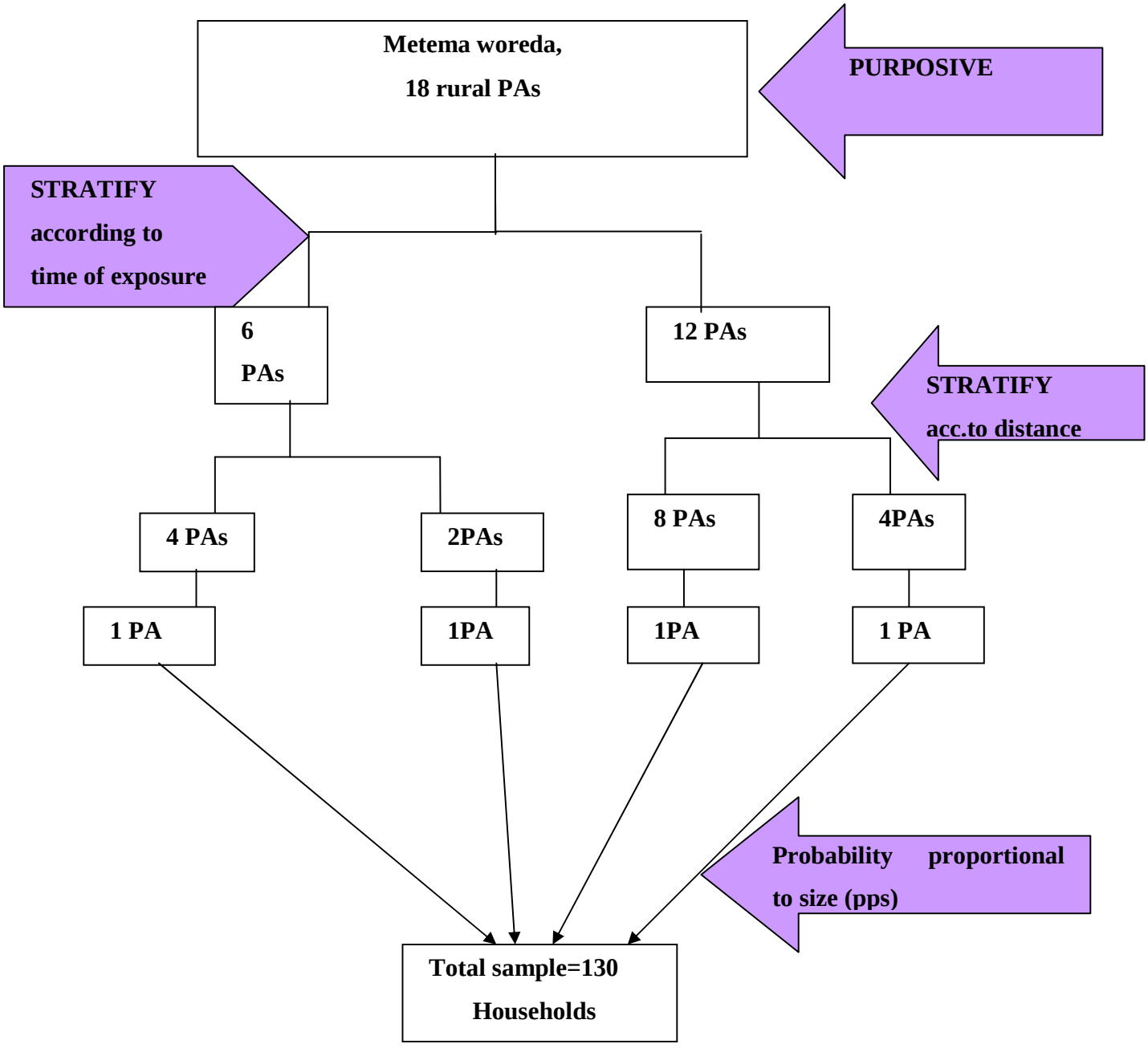

Figure 4 **:** Sampling procedures

A sampling frame is then established by listing all farmers living in the 4 PAs growing sesame, sorghum or teff during the study year. In this study, adopter of CT technology is defined as farmers who were practicing either zero tillage in association with non-selective herbicides or zero tillage only on at least one plot in 2 cropping season. Conversely a non-adopter is one who practiced conventional tillage in all of the plots.

Table 1 Distribution of sample respondents per each sample PA

Name of Sample PAs	Total No of HHs	%	No of Sample HHs
Kokit	1660	36.5	47
Das Michael	1302	28.6	37
Gubay Gegebit	946	20.8	27
Metema yohannes	639	14	19
Total	4547	100	130

Source: own survey, 2010**.**

3.3 Data types and data sources

In this study, both qualitative and quantitative data were collected to attain the stated objectives from primary and secondary data sources. The primary data sources are male and female respondents, key informants, as well as DAs and experts. Secondary data were collected from documents, records and reports of GOs and NGOs.

3.4 Methods of Data Collection

3.4.1 Quantitative Data collection

The primary quantitative data were collected from the respondents using a pre- tested, structured interview schedule by enumerators who were familiar to the existing social settings. Training was organized in the woreda town to enumerators on the content and interview techniques. Finally, the survey was conducted under close supervision of the researcher. The interview schedule for primary data collection included both open-ended and closed-ended questions. Secondary quantitative data were collected from reports of Wereda Agricultural and Rural Development Office and IPMS project learning site office.

3.4.2 Qualitative Data Collection

Qualitative data were collected through discussions with focused groups and key-informants, field visits, observations and case studies.

In the focused group discussion, the interviewer guided the discussion among a small group of six to eight members of the community using a semi- structured check list. The facilitator introduced a list of topics and encouraged the participants to discuss issues and forward their opinions. In addition, discussion with Kebele and Wereda officials, DAs and concerned wereda Agricultural office experts were held.

3.5 Methods of Data Analysis

Following the completion of the data collection, the data were coded and entered into Statistical Package for Social Science (SPSS version 16) computer program for analysis.

3.5.1 Qualitative data analysis

Qualitative data were analyzed using different qualitative statistical procedures and methods. Descriptive tools were supplemented by qualitative analytical methods (mainly for those data acquired through the participatory/ qualitative methods) like interpretation and explanation of various opinions, views and concepts; and summarizing, categorizing, and presentation of these in convenient forms.

3.5.2 Quantitative data analysis

Descriptive statistical tools were used to analyze the quantitative data. The important statistical measures that were used to summarize and categorize the research data were means, percentages, frequencies, standard deviations, chi-square and t-test. The degree of association or correlation between two variables X and Y was answered by the use of correlation analysis (Gomez and Gomez, 1984; Kothari, 2003).

In most of the studies on adoption behavior, the dependent variable can be effectively captured using binary choice models. Binary choice models are appropriate when the decision making choice between two alternatives depends on the characteristics of the problem. Three types of models have been proposed in the econometric literature for estimating binary choice models: the linear probability, logit, and probit models represented by linear probability function, logistic distribution function, and normal distribution function, respectively (Gujarati, 1995).These functions were used to approximate the mathematical relationships between explanatory variables and the adoption decision that is always assigned qualitative response variables.

The interest of the study is to analyze the factors influencing the decisions of households to use conservation tillage technology. The response to questions such as whether a household has used conservation tillage involving non-selective herbicide in association with zero tillage or not could be yes or no, which is a typical case of dichotomous dependent variable. Hence a binary logit model is used to analyze the factors influencing CT technology among sample

farmers.

Model specification

Following Maddala (1992), Green (2008) and Gujarati (2003) the logistic distribution for the adoption decision of conservation tillage technologies can be specified as :

$$p_i = \frac{1}{1 + e^{-z(i)}} \quad \text{..... (1)}$$

Where, Pi is a probability of adoption of conservation tillage technologies for the i^{th} farmer and ranges from 0 to 1. e- Represents the base of natural logarithms and Z_i is the function of a vector of n explanatory variables and expressed.

$$z_i = \beta_o + \sum \beta_i X_i \text{ ..... (2)}$$

Where B_o is the intercept and B_i is a vector of unknown slope coefficients.

The relationship between P_i and X_i, which is non-linear, can be written as follows:

$$p_i = \frac{1}{1 + e^{\beta_0 + \beta_i + x_i + ... \beta_n x_n}} \quad \text{..... (3)}$$

The slopes tell how the log-odds in favor of adopting the technology changes as independent variables change. If Pi is the probability of adopting given technologies, then 1-Pi represents the probability of not adopting and can be written as:

$$1 - p_i = \frac{1}{(1 + e^{-zi})} = \frac{e^{-zi}}{(1 + e^{-zi})} = \frac{1}{1 + e^{zi}} \text{ ..... (4)}$$

Dividing equation (1) by equation (4) and simplifying gives:

$$\frac{p_i}{1-p_i} = \frac{1+e^{zi}}{(1+e^{-zi})} = e^{zi} - \text{......................................} \quad (5)$$

Equation (5) indicates simply the odd-ratio in favor of adopting the technologies. It is the ratio of the probability that the farmer will adopt the technology to the probability that he will not adopt it. Finally, the logit model is obtained by taking the logarithm of equation (5) as follows.

$$L_i = L_n\left[\frac{p_i}{1-p_i}\right] = z_i = \beta_o + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_n x_n \text{ .... } (6)$$

Where Li is log of the odds ratio, which is not only linear in X, but also linear in the parameters: Thus, if the stochastic disturbance term Ui is taken into account, the logistic model becomes:

$$z_i = \beta_o + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_n x_n + U_i \text{ ....} (7)$$

This econometric model is estimated using the iterative Maximum Likelihood Estimation (MLE) procedure due to the nonlinearity of the logistic regression model. The MLE procedure yields unbiased, asymptotically efficient, and normally distributed regression coefficients (parameters).

3.6 Definition of variables and working hypothesis

Dependent variable

Adoption of conservation tillage is a dichotomous type represented by a value of 1 if a farmer used either non selective herbicide and practicing zero tillage or only zero tillage at least in one of his farms for the last 2 years and a value of 0 otherwise (practiced conventional tillage).

Independent Variables

Age of the household head. This variable refers to the chronological age of household head at the time of the survey, measured in years. As the age of the household head increases, the probability of using CT is likely to decrease. Because, with age, a farmer can become more risk averse and then tend to be reluctant to new technologies. Therefore, it is hypothesized that age of household head are more likely to affect conservation tillage technology negatively (Kidane, 2001).

Education. It measures formal education of household head in the family .It is a dummy variable, which takes a value 1 if the farm household is literate (can only read and write), and 0 illiterate. Education increases farmers' capacity to create or innovate. Farmers having a good education level are more open to new technology. The study hypothesized that educational level would be positively related to technology adoption (Habtemariam, 2004; Million and Belay, 2004).

Farming experience. is to be measured in number of years of experience in farming. Farmers with higher experience appear to have often-full information and better knowledge and might be able to evaluate the advantage of the technology (Chilot *et al.*, 1996). Hence, farming experience is hypothesized to affect adoption of CT positively.

Access to credit. This variable is measured in terms of whether respondents have access to credit, in-terms of availability of credit sources and possibility of getting credit. It is a dummy variable, which takes a value 1 if the farm households have used credit or 0, otherwise. Farmers who have access to credit may overcome their financial constraints and therefore be able to buy inputs. Farmers without cash and do not have access to credit may find it very difficult to attain and adopt new technologies (Mekonnen, 2007; Minyahel, 2007 and Taha, 2007). Hence, access to credit is expected to increase the probability of adopting CT technology.

Contact with extension agents. This refers to the number of contacts per year for conservation tillage technology that the respondent made with extension agents and it is a continuous

variable.Contact with extension agent is hypothesized to increase farmers' likelihood of adopting the technology (Degnet, 1999; Tesfaye *et al*., 2001; Habtemariam, 2004). The higher number of contacts the farmer had with extension personnel the higher the exposure to CT technology, and the more likely the adoption. .

Participation in training. Training is one of the means by which farmers acquire new knowledge and skill. It is measured as the number of times the farmer has received CT technology training in the last three years (Tesfaye and Alemu, 2001).Hence, participation in training is expected to positively influence farmers' adoption behaviour.

Participation in field days. It is measured as the number of times the farmer has participated in CT technology field days in the last three years (Taha, 2007). Participation in field days is expected to positively influence farmer's adoption level of the technology.

Access to mass media. This variable is measured as a composite score in an ordinal scale. It is measured in such a way that a person who has access to all the three media (Radio, TV and print materials) received a value of 3. In similar fashion farmers reported accessing to two; one and none received a value of two, one and zero, respectively. Access here is defined as ownership of the media and having time and ability to use it. It is expected that access to mass media to have positive association with the adoption of conservation tillage (Yishak, 2005; Ebrahim, 2006).

Herbicide price. This variable is measured on five-point scale based on farmers' perception as very expensive, expensive, moderately expensive, less expensive and not expensive. It is hypothesized that the higher the perceived price of herbicide, the lower the likelihood of using CT.

Land holding size. In the present investigation, farm size is defined as total farm size owned and rented by the household head in hectares. It is a continuous variable, measured by the number of hectares, including area owned and rented. Farm size is expected to motivate farmer's adoption of new technologies (Mesfin, 2005).

Number of Livestock Owned (TLU): This variable is defined in terms of Tropical Livestock Unit (TLU), may serve as a proxy for the capacity to bear risks of using new technology such as improved technologies (Chilot *et al*., 1996; Asfew *et al*.,1997; Habtemariam, 2004). Households that have large number of livestock were assumed to adopt innovation better than others who have less number of livestock.

Active family labor force. It refers to the active family male and female labor between 15 and 64 years of age. Labor is measured in Man Equivalent. A household with larger number of workers per hectare (unit) is more likely to be in a position to try and continue to use a potentially profitable innovation. In addition, it is expected to influence adoption positively (Kidane,2001).

Participation in off-farm income activities. This variable refers to participation of the respondents in income generating activities out of his/her own farm. Income from selling of farm produce, working as laborer in other farms, etc., at the study time. It is measured by the amount of birr obtained from these activities. Off-farm income increases the probability of adoption of new technologies foe additional income earned from off farm activities may augment the farmers' financial power, which in turn enable farmers to adopt new technologies by enhancing the household's access to inputs (Brihanu, 2002; Ebirahim, 2006; Taha, 2007). Therefore, it expected that participation in off-farm activities are likely to positively influence adoption CT technology.

Participation in non-farm income activities: This indicates whether the respondent is participating in non-farm income generating activities. . It is measured by the amount of birr obtained from these activities. Additional income earned from outside agricultural activities increases the farmers' financial capacity and increase the probability of investing on new technologies (Chilot *et al*, 1996; Asfew *et al*, 1997; Habtemariam, 2004). It is therefore, expected to affect adoption positively.

Perception of the technology. The perception of technology on each component is taken to be continuous and measured in a range, from 1 to 4 scales,1=less important,2=important,3=more important,4= highly important. In this study, weighted average of individual positive (advantages) and negative (disadvantages) was calculated and total advantage and disadvantage was calculated. Then total perceived attribute of the technology would be taken as the difference between the two. Perception about a technology directly influences adoption of a technology at HHs level. HHs has different perception on the same technology and this might affect adoption positively.

Social Participation. A person's affiliation and involvement in social activities or the involvement of a person in any formal or informal organization are likely to expose the individual to different knowledge. Individuals actively involving in various social activities are likely to have a better awareness and utilize for the knowledge than those who did not involve in social activities (Chilot et al, 1996; Asfew et al, 1997; Habtemariam, 2004). The variable was measured by allocating a score of 1 if a farmer is member of one social organization, 2 if a farmer is committee member of one social organization and a score of 3 was given if a farmer is leader of one social organization and for frequency of participation scores of, 0, 1 and 2 was given never, sometimes, and when ever conducted, respectively. Total score achieved by household head from 9 listed social organizations were considered. The higher is the number of social organizations the farmer is involved the higher the likelihood of adopting CT technology.

Information seeking behavior - this is defined as the degree to which the respondent is eager to get information from various sources on different roles s/he performs (Gogoi, 1990). It was measured in terms of quantity and frequency of information eager to get on weighted score basis. Information seeking behavior is assumed to have positive relationship with the dependent variable.

Cosmopoliteness. It is the degree of orientation of the respondents towards outside social system to which he/she belongs. This variable is measured as a composite variable. It is measured in terms of frequency of visits outside his/her village and the purpose of such visits. Cosmopoliteness was expected to have positive relationship with the adoption of the technology (Mekonnen, 2007).

Table 2. Definition and units of measurement of the variables

Variables	**Description and measurement**
Age	Age of house hold (in years)
Active labor force in the family (adult male and adult female)	Active family Labor (man equivalent).
Education	Formal education of household head (dummy=1,only read and write; 0=illiterate)
Experience in farming	Farm experience of household (years). In Metema, other parts of the country and abroad.
Land holding size	Farm size of household (hectare).
Number of livestock owned	Total livestock owned by the farm household (TLU).
Access to credit	Access to credit in which the farmer gets (=1, if yes; =0, otherwise)
Contact with extension agent	Frequency of time extension agent visited/advised farmer (weekly, monthly,e.t.c) for CT technology
Participation in CT technology training	Frequency of participation in CT technology training
Participation in CT technology field days	Frequency of participation in CT technology field day

Participation in off-farm income activities	In -come earned from off-farm(continuous).
Participation in non -farm income activities	In- come earned from non-farm activities (continuous).
Information seeking behavior	The frequency of the farmer to get information.
Access to mass media	The frequency of using Radio, TV, or print material (ordinal).
Herbicide price	Discrete variable, and measured in five point scale (high-low).
Perception of technology	Total perception of the technology
Social participation	Total participation of the farmer in social activities
Cosmopoliteness	The frequency of contact the farmer has with situations of the social system (daily, weekely, monthly etc) and purpose of visit.

4. RESULTS AND DISCUSSION

This chapter deals with the analyses and interpretation of major findings of the study on the adoption of conservation tillage technology in Metema woreda. These are demographic variables of farm households, the rate of adoption of conservation tillage technology, knowledge sharing among farmers in adoption of conservation tillage technology, description of factors affecting conservation tillage technology and factors affecting conservation tillage technology based on the interpretation of the model output of binary logit of the study and leading to the conclusion and recommendations made in the final chapter.

4.1. Adoption of conservation tillage technology in Metema woreda

Table 3 summarizes the level of use of conservation technology among the study sample as of year 2010. As noted earlier, an adopter in this study is defined as one who used either zero tillage alone or zero tillage in combination with the pre-emergence herbicide (round up) on at least one of the plots for the last two years. Accordingly, slightly more than half of the respondents adopted conservation tillage in the study area.

Table 3. Rate of Adoption of conservation tillage technology in MetemaWoreda, 2010.

Adoption of technology	N	%
Non- adopter	31	23.85
Dis-adopters	28	21.55
Zero tillage +herbicide	4	3.08
Only zero tillage	67	51.52
Total	130	100

Source: Own survey, 2010

4.2 The role of farmer-to-farmer knowledge sharing

This section covers knowledge sharing among total sample respondents and actors with respect to knowledge sources, knowledge sharing contents, quantity and frequency of knowledge in terms of new practices, importance of shared knowledge items, methods utilized for knowledge sharing and knowledge network on conservation tillage technology.

Knowledge sources in terms of practices used in CT and frequency of this practices were analyzed to assess the role of farmers in knowledge sharing of conservation tillage practices among farmers. The amount of knowledge and its frequency from different actors were identified and presented in Tables 4 and 5, respectively.

The most important sources of knowledge for the study sample were friends, and this is probably due to friends shared knowledge for most practices during their meeting and at group work. As another key source, Friends and Neighbors provided knowledge on most practices. Development agents and Radio were third and forth respectively which indicate that farmer's social networks used for knowledge sharing of most new practices among them. These findings agree with the findings of Dereje (2005) and Deribe (2007).

Table 4. Knowledge sources in terms of practices of CT (n=130)

Knowledge sources	Practices of Knowledge						score	Rank
	Most practices		Some practices		None			
	N	%	N	%	N	%		
Friends	70	53.8	50	38.5	10	7.7	190	1
Neighbors	61	46.9	51	39.2	18	13.8	173	2
Development agents	59	45.4	46	35.4	25	19.2	164	3
Radio	23	17.7	38	29.2	69	53.1	84	4
Woreda agricultural office	11	8.5	44	33.8	75	57.7	66	5
Farmers groups	7	5.4	37	28.5	86	66.2	51	6
Relatives	5	3.8	37	11	88	67.7	47	7
Informal social groups	1	.8	32	24.6	97	74.6	34	8
IPMS	3	2.3	10	7.7	117	90	16	9
Pamphlets	0	0	16	12.3	114	87.7	16	9

Source: Own survey, 2010.

The less important in sourcing practices of knowledge are IPMS and pamphlets, probably due to less access of NGOs and less educational status of the farmers. The findings suggest that attention should be given to provide relevant information through NGOs and available Media to farmers which are practicing conservation tillage as well.

Table 5: Knowledge sources in terms of frequency (N=130)

Knowledge sources	frequency of practices of CT						score	Rank
	Most practices		Some practice		None			
	N	%	N	%	N	%		
Friends	60	46.2	59	45.4	11	8.5	179	1
Neighbors	62	47.7	47	36.2	21	16.2	171	2
Development agents	58	44.6	47	36.2	25	19.2	163	3
Radio	18	13.8	43	33.1	69	53.1	79	4
Woreda agricultural office	9	6.9	44	33.8	77	59.2	62	5
Farmers groups	9	6.9	32	24.6	89	68.5	50	6
Relatives	5	3.8	37	28.5	88	67.7	47	7
Informal social groups	2	1.5	33	25.4	95	73.1	37	8
IPMS	1	.8	13	10	116	89.2	15	9
Pamphlets	1	.8	13	10	116	89.2	15	9

Source; own survey, 2010.

As indicated in Table 5, friends stood first in frequency of knowledge sharing; probably they had more opportunity to contact frequently. The same result was getting with regard to quantity and frequency of knowledge sharing from neighbors and development agents. This finding showed that farmers got more information easily from their friends and neighbors than other sources available in the area.

4.2.1 Farmer-to-Farmer Knowledge Sharing

As discussed in the previous section, most knowledge was shared among farmers in differential quantity as well as frequency. With respect to the interaction level in knowledge sharing for each knowledge item was analyzed and presented in Table 6.

Table 6. Farmer -to- farmer knowledge sharing (N=130)

	Knowledge sharing							
Knowledge item	In all farming interaction		Whenever asked		Only/some times		Score	Rank
	n	%	N	%	n	%		
Spraying of herbicide based on recommendation	64	49.2	44	33.8	10	7.7	290	1
Quantity of herbicide used	44	33.8	59	45.4	14	10.8	264	2
Quality of herbicide	41	31.5	58	44.6	17	13.1	256	3
Time of spray	42	32.3	50	38.5	26	20	252	4

Source: own survey, 2010.

Farmers shared knowledge according to the knowledge required for the specific activity. Whether the activities are day to day activity or seasonal, technical knowledge were shared among farmers based on their interest.

The household survey results indicated that spraying of herbicide based on recommendation, quantity of herbicide used and quality of herbicide techniques were the frequently shared knowledge items and scored first, second, and third respectively in farmer to farmer knowledge sharing interaction. Time of spray was the last knowledge item shared among farmers.

4.2.2 Knowledge sharing in terms of receivers

As discussed in the previous section, conservation tillage practices were shared among farmers in different levels, but about the question with whom farmers have shared their technical knowledge are presented in Table7.

Table 7. Knowledge sharing in terms of frequency of receivers (n=130)

Knowledge shared to	Knowledge sharing frequency							
	Mostly		Sometimes		Never		Score	Rank
	n	%	n	%	N	%		
Friends	89	68.5	26	20	15	11.5	204	1
Neighbors	74	56.9	29	22.3	27	20.8	177	2
Adjacent farmers	68	52.3	28	21.5	34	26.2	164	3
Relatives	38	29.2	38	29.2	54	41.5	114	4
Farmer group members	25	19.2	41	31.5	64	49.2	91	5

Source: own survey, 2010.

Most of respondent farmers have been sharing their knowledge to friends, and this might be because most of the time they contact with their friends. The second was neighbors who had an opportunity to meet each other's frequently and exchange experiences among them. Adjacent farmers and relatives stood third and fourth respectively, who might have received new knowledge mostly through their social interaction. Farmer group members stood last and this is because of weak interaction between farmer group members.

4.2.3 Occasions of knowledge sharing

This sub section indicated the occasions used by sample farmers for knowledge sharing and information exchange among them in relation to conservation tillage technology at the study area.

Table 8 . Occasions of knowledge sharing in terms of frequency(n=130)

	frequency							
	Mostly		Sometimes		Never		Score	Rank
Knowledge sharing occassions	n	%	N	%	n	%		
Farmers at work	93	71.5	22	16.9	15	11.5	208	1
Interpersonal communication	68	52.3	34	26.2	28	21.5	170	2
Market day	53	40.8	39	30	38	29.2	145	3
During group discussion	41	31.5	36	27.7	53	40.8	118	4
During cooperative assembly	10	7.7	43	33.1	77	59.2	63	5
Demonstration and field day	14	10.8	24	18.5	92	70.8	52	6

Source: own survey, 2010.

Farmers mostly share their knowledge during working at their farm. The knowledge focuses on practical methods like, how to spray, amount used for 1 ha and when to spray of the chemical.

The second and third important occasions were interpersonal communication and market day. This might be due to the strong social net work of the area. Followed by group discussion, cooperative assembly and during demonstration and field day were the fourth, fifth and sixth occasions respectively. Field days have been arranged by DAs at their locality to show how to use the herbicide and when to apply each other as required. Demonstrations were carried out by IPMS project and Woreda Agricultural Office in collaboration during introducing the herbicide which was participating by many farmers in the first introduced PAs. Knowledge sharing during demonstration and field day was the least method; the reason might be that demonstrations were prepared only once in a year and participant farmers were very limited.

4.2.4 The knowledge network

Based on the household survey of sample respondents, the offered knowledge and types of knowledge reached to different client groups from actors were very low.

The most important but not offered knowledge to both groups was quality identification of the herbicide and amount of the herbicide used per hectare. That means the knowledge system does not provide all the relevant knowledge. On the other hand, even if the knowledge reached to all client groups, it does not mean that all of them received exactly the same amount and frequency of knowledge. Separate group discussion of each categories confirmed that except quality identification information, knowledge items were reaching most of the clients; this was done mostly through farmer- to- farmer knowledge sharing, group discussion, and interpersonal communication.

4.3. Description of Factors Affecting Adoption of Conservation Tillage

Personal and demographic variables

Educational level of the respondents (EDU HH)

Most of the households are similar in their status of education. Before the survey was conducted education was classified into four categories; illiterate, only read and write, grade 4-10 and above grade 10. After actual data collection the respondent farmers fall in two categories. The distribution of total sample respondents in terms of literacy level has shown that 47% were illiterate and 53% can only read and write.

The results of this study show that 56.3% of adopters were literate and 43.7% were illiterate and from non-adopters49.2% were literate and 50.8% were illiterate. In this study, levels of education have no association with adoption of CT technologies (Table 9). The finding of this study is in agreement with Rahmeto (2007), but inconsistent with many of the previously conducted studies. For example, Tesfaye *et al*., (2001) reported a positive and significant relationship of education with adoption.

Table 9. Association between educational status of the household head with adoption (n=130)

Educational status of HH head	Adopter category		χ^2 –value	p
	Adopter (%)	Non adopter(%)		
Illitrate	43.7	50.8		
Only read &write	56.3	49.2		
Total	100	100	.668	.414

Source survey data, (2010). Ns:Non- significant.

Age of the HH head (AGE HH)

In adoption of new agricultural technologies, farmers' age has an influential effect as hypothesized in many adoption studies.

As indicated in Table 10, the mean age of adopters was 44.15 and 38.51% for non-adopters with a standard deviation of 8.774 and 9.383. To check whether there is a significant mean difference in age between adopters and non-adopters t-test Statistics was run. The result of t-test showed that there was statistically significant mean age difference between adopters and non-adopters at 1% significance level. The survey result indicates that as a farmer increases in his age his ability to accept new technology increases and age affects conservation tillage technology positively, as against the hypothesis.

Farm experience of respondent farmers (FAEXHH)

Farm experience is one of the household characteristics, which a farmer acquired in his life by undertaking farming activities. Farmers can observe success and failure in crop production or otherwise. Therefore, this could help them to weight between the performance of a modern and a traditional technology, and to develop more confidence to take risks related to farming. It is also an important factor for success in farming. This is because; as farming age increases farmers can gain more information about farming.

On average, the sample respondents had about 15.99 years of farm experience. The finding of this study shows that mean farm experience of adopter was about 20.33. On the other hand, mean farm experience of non-adopter was 10.76 years. This study has identified that about 30% of the respondents have less than 10 years of farm experience, whereas around 37.6% of them had 20-40 years experience. The result reveals that adopters had more years of farm experience than non-adopters. To check whether there is a significant mean difference in farm experience between adopters and non-adopters t-test Statistics was run. The result of t-test showed that there was statistically significant mean difference between adopters and non-adopters at 1%

significant level as shown in table 10.

Table 10. Association between Personal/demographic variables with adoption (n=130)

Variables		Adopter category		t	p
		Adopter	Non adopter		
Age of HH head	Mean	44.15	38.51		
	SD	8.774	9.383	-3.540	.001***
Farm experience	Mean	20.33	10.76	-7.562	.000***
	SD	8.56	5.05		

Source survey data (2010), ***Significant at less than 1% level.

Economic variables

Total land holding (LAHOSZ)

According to the sample survey data, the average land holding of sample households was 8.66 ha with standard deviation of 10.9, which is larger than the national figure, which is 1.5 ha implying relatively better holding in the area.

Table 12 clearly indicates that, the average land holding for non-adopter group was 6 ha with standard deviation of 4.96 while adopters were 10.88 ha and 13.63 standard deviation. The results of independent sample t-test (with value of t=-2.609) shows a statistically significant mean difference between adopters and non-adopters at 1% significant level. The result of this study confirms the earlier findings of Getahun (2004), Mesfin (2005), Rahmeto (2007) and Taha (2007).

Number of livestock owned (TLTLU)

The result of this study indicated that livestock holding of sample population ranges from 0.00 to 57.81 TLU implying the existence of large variation among the households in livestock ownership. The average livestock holding of the sample population was 7.3 TLU with standard deviation of 8.268 TLU.

As indicated in Table 12, non adopters of conservation tillage technology had average livestock holding of 5.29 TLU and adopters had 8.97 TLU. Test of mean difference using independent sample t-test showed that there was significant mean difference (t=-2.580) between adopters and non-adopters at 1% significance level. This clearly shows the significant role of livestock holding in adoption of conservation tillage technology.

Regarding relationship of livestock holding with adoption, many adoption studies so far conducted have also reported similar results. To mention some, for instance, Degnet and Belay (2001), Kidane (2001), Birhanu (2002), Techane (2002), Endrias (2003), Yishak (2005) and Rahmeto (2007) have found that livestock holding has positive and significant influence on adoption of improved agricultural technologies.

Active family labor force (AFLAB)

Family labor was assumed to be the main source of labor required for farm operations such as land preparation, planting, weeding, and harvesting. Hence, information was generated on labor availability of sample households in order to examine the influence of labor availability on adoption of conservation tillage technology.

Table 11. Distribution of respondents in relation to labor shortage problem and its solution in relation to CT technology(n=130)

Labor shortage problem	N	%	Solution to labor shortage	N	%
No	21	16.2	No problem	11	8.5
Yes	109	83.8	hiring	104	80
			Use 'debo'	13	10
			Both hiring and 'debo'	2	1.5
Total	130	100		130	100

Source own survey data,2010.

The survey result presented in Table 11 reveals that 109 of the respondents reported facing labor shortage during different farm operations. The most farming activities affected by labor shortage in the study area were land preparation, weeding and harvesting. The survey result shows in weeding 35.4% and 63% in all activities including weeding faces labor shortage. Moreover, it also shows that 80%, 10 % and1.5 % of respondents reported using hiring, asking cooperation (debo) and both hiring and cooperation, respectively as solution to labor shortage problem.

The man equivalent (ME) family labor availability was calculated for the sample respondents (Appendix Table 1). The survey result on labor availability across adopter categories in Table 12 shows that, the average number of available labor force in terms of man equivalent for non-adopters was 2.5 with standard deviation of 1.24 and for adopters 3.07 with standard deviation of 1.49.

The size of labor force in the household is expected a priori to contribute for variation on adoption decision of CT technology. This study shows significant difference with regard to the

size of labor force between adopters and non-adopters. This is evident from the result of independent simple t-test (t= -2.307, p=.023) which shows significant mean difference between adopter and non-adopters at 5% significance level (Table 12). The result of this study is different from the earlier findings of Getahun (2004), Yishak (2005),Rahmeto (2007) and Almaz(2008).

Participation in off- farm activities (OFFFAM)

Off farm activity is one of the most important means to generate additional income. The most common off farm activity in the study area was working as daily laborers outside their farm.

About 15.4 % of the sampled farmers were engaged in this activity. Out of these, adopters accounted for about 15.5%, while non-adopters comprise 15.3%. The mean annual income generated from off farm activities was 1287.32 for adopter while 908.47 Birr for non-adopters. However, the difference was statistically tested and it was found to be insignificant (t=-.448,p=.655)(Table 12).

Participation in non-farm activities (NONFAM)

During slack periods, many farmers can earn additional income by engaging in various non-farm activities. This is believed to raise their financial position to acquire new inputs. In the study district, petty trading, daily labor activities, house making were found to be some of the non-farm activities in which sample households were participating. Out of the total households interviewed 15.4% had participated in non-farm activities. Among the households who participated in non-farm activities, adopters accounted about 15.5 % while non-adopters accounted 15.3% with slight difference in terms of percentage (Appendix 5).

Participation in non-farm activities had insignificant relationship with adoption of CT technology. Participation in non- farm and off farm activities gives the same result. The only difference is the mean income from these activities. The mean annual income generated from nonfarm activities for adopters were 1237.32 birr and 1081.36 for non adopters(table12). The

probable reason might be most of the farmers in the study districts are dependent on crop production as well as animal and animal products. This implies most of the farmers in the study areas relay on on-farm income rather than non and off- farm income. The results of this study is different from the findings of Kidane (2001), Birhanu (2002), Getahun (2004), Mesfin (2005), Taha (2007) and Almaz (2008).

Table 12. Association between Economic variables with adoption (n=130)

Variables		Adopter category		t	p
		Adopter	Non- adopter		
Total land holding	Mean	10.9	6.0		
	SD	13.6	4.9	-2.609	.010***
Livestock(TLU)	Mean	8.9	5.3		
	SD	8.9	6.9	-2.580	.011***
Active labor force	Mean	3.07	2.5		
	SD	1.5	1.3	-2.307	.023**
Non-farm	Mean	1237.3	1081.4		
	SD	4709.9	3577.4	-.209	.835^{ns}
Off-farm	Mean	1287.3	908.5		
	SD	5324.2	4084.04	-.448	.655^{ns}

Source own survey data (2010), ***significant at 1% level, ** significant at 5%level,ns= non-significant.

Herbicide price (HERPRI)

Input and output prices influence adoption decision process in a contradicting aspect. An increase in output price encourages farmers to adopt new technology while an increase in input

price makes them decrease adoption of the technology. Agricultural product prices are fluctuating due to lack of market infrastructure and services as well as market information system. In the study area, where there is lack of physical and institutional structures that can promote marketing facilities and fair price of products.

During the focused group discussion and key informants interview, increasing trend on herbicide market price was observed especially on cropping times. There is also difficulty to get on time.

As indicated in Table 13, farmers have perceived the price of herbicide in relation to hand weeding and plowing was moderately expensive (36.2%) while 31.5% respondents have been less expensive, 24.6% ,not expensive and 7.6% of the farmers perceived as either expensive or very expensive. In regard to herbicide availability on time and quantity from the total sample respondents 16.2% perceive not available on time while 83.8 % shows available on time and quantity. But, it was contradictory with the information collected during group discussion. This is due to the fact that most farmers can get herbicides on local shops and the price is not a problem for them as compared with labor cost. The chi-square test result ($\chi 2$=.537 and P=.464) for availability of herbicide on time and quantity showed that there was insignificant difference between adopters and non-adopters (Table 13).

Table 13.Farmers perception on herbicide price and availability on time and quantity (n=130)

Response category			Availability on time and quantity		
Herbicide price	N	%		N	%
very expensive	5	3.8	No	21	16.2
expensive	5	3.8	Yes	109	83.8
Moderately expensive	47	36.2			
Less expensive	41	31.5			
Not expensive	32	24.6			
Chi-square			.537		P=.464^{ns}

Source own survey data, 2010. ns=non-significant

Extension /communication variables

Extension contact (EXVST)

Extension contact is supposed to have a direct influence on the adoption behavior of farmers. When there is contact with extension agent, the greater is the possibility of farmers being influenced to adopt agricultural innovations. The village level worker is one of the most important sources of information on agricultural innovations to farmers, especially those who are earlier adopters. Later adopters, however, tend to rely more for information on relatives, friends, and neighbors who have already tried out the innovation and adopted.

Table 14. Association between contact with extension agent and adoption

Contact with extension agent	Adopter		Non-adopter		Total		χ2-value	p
	N	%	N	%	N	%		
Yes	68	95.8	46	78	114	87.7		
No	3	4.2	13	22	16	12.3		
Total	71	100	59	100	130	100	9.469	.002***

Source own survey data, 2010. Significant at 1%.

The result on sampled farmers contact with extension agent indicated that of the total 130 sample respondents, 114(87.7 percent) farmers reported having contact with development agents and 16 (12.3 percent) farmers reported having no contact with development agents (Table 14). This has a serious implication with respect to management of development agents (existing monitoring and evaluation, reward and punishment), particularly having three development agents per each rural *kebele.*

The Table also illustrates that 78% of non-adopters and 95.8% adopters had contact with extension agents. The chi-square result ($\chi2=9.469$ and P=.002) shows there was statistically significant difference between adopters and non- adopters with respect to farmers' contact with extension agent.

The result of this study indicated that contact with extension agent is influencing adoption positively. This agrees with priori expectation and confirms the study carried out by Teferi (2003), Abrhaley (2006) and Almaz (2008).

Frequency of contact with extension agent (FOEXVST)

This refers to the number of contacts per year that the respondent made with extension agents. The effort to disseminate new agricultural technologies is within the field of communication between the change agent (extension agent) and the farmers at the grass root level. Here, the frequency of contact between the extension agent and the farmers is hypothesized to be the potential force which accelerates the effective dissemination of adequate agricultural information to the farmers, thereby enhancing farmers' decision to adopt new crop technologies.

The score for frequency of contact with extension agent was calculated on the basis of scores, score of zero was given for having no contact with extension agent, score of 1 was given for those who have contact once in a year, 2 was given for those who have once in six months contact with extension agent, and score of 3 was given for those who have monthly contact with the extension agents, a score of 4 given for those having bi-weekly contact with the extension agent and a score of 5 given for those having weekly contact with the extension agent. Accordingly, the maximum score to be achieved by a farmer was 5.

Table 17 shows that the average score of adopters was 2.44 with standard deviation of 1.41 and for non-adopters .966 with standard deviation of 1.085. The independent sample t-test showed that there was significant mean difference (t=-5.64, p=0.000) between adopters and non-adopters in relation to score achieved for frequency of contact with extension agent. This result agrees with the finding reported by Kidane (2001), Girmachew (2005), Abrhaley (2006) and Rahmeto (2007).

Mass media exposure (FREMMED)

The adoption process of agricultural technologies depends primarily on access to information and on the willingness and ability of farmers to use information channels available to them. Mass media exposure was also hypothesized to be one of the determinant variables to affect adoption of conservation tillage technologies. Accordingly the survey results on media exposure

(exposure to radio, TV and printed Medias) were assessed. Table 15 presents distribution of sample respondents per mass media exposure.

Regarding mass media exposure of sample respondents in the study area suggests that 79.2%, 69.2%, 64.6%, 58.5% and 16.2 % of sample respondents did not use manuals, pamphlets, leaflets, TV and radio as source of information, correspondingly. However, 49.2% and 4.6% of respondents were found to be daily listening to radio and TV, respectively. Surprisingly, majority of radio and TV listeners as well as printed media readers in the study areas do not pay attention to agricultural programs. Lack of attention to agricultural program may be attributed to not have awareness on the importance of the program and also lack of favorable attitude towards the program.

Table 15. Distribution of respondents per mass media exposure (n=130)

Mass media	Frequency of mass media exposure average score (%)			
	Never	Rarely	Sometimes	Always
Use radio	16.2	6.9	27.7	49.2
Use TV	58.5	16.2	20.8	4.6
Use leaf lets	64.6	11.5	22.3	1.5
Use pamphlets	69.2	10	20	.8
Use manuals	79.2	7.7	12.3	.8

Source own survey data, 2010.

In this study, respondent farmers' exposure to mass media was measured on five-point scale and total mass media exposure constituted a total score of 20. As shown in Table 17, the t-test indicated there was insignificant mean difference (t=-.483, p= 0.630) between adopters and non-adopters. The result of this study is consistent with the findings of Kidane (2001), Getahun (2004) and Rahmeto (2007). This could be due to the fact that agricultural radio programs were not given top priority by farmers of study area rather the priority was for other non agricultural programs.

Utilization of credit (CREDIT)

Credit service is also another component of economic variables that influences adoption of agricultural technologies, especially for poor farmers to relax the limited finance for purchasing agricultural inputs.

As presented in Table 16, from the total sample households only 30% (n=39) were used credit to purchase herbicide. Majority of the sample households purchase the herbicide on cash. The Table also illustrates 33.8% of adopters and 25.4% of non-adopters used credit and 66.2% from adopters and 74.6% from non-adopters were non users. The chi-square test shows that there is no significant difference between adopters and non adopters with respect to credit use ($\chi 2=1.077$, $p=0.299$).The result of this study is in agreement with the findings of Abrhaley (2007).

Table 16. Distribution of households by credit utilization (2009/2010 cropping season).

Credit use For non-selective herbicide	N	%	Adopters		Non-adopters		$\chi 2$-value
			N	%	N	%	
No	91	70	47	66.2	44	74.6	
Yes	39	30	24	33.8	15	25.4	
Total	130	100	71	100	59	100	1.077^{ns}

Source own survey data, 2010. ns=non-significant.

Attending extension events

Attending field visit and training (FIELD PAR-TRAIPAR)

The other means through which farmers get agricultural information is through participating in different extension events arranged by different institutions. These include training, field

day/visit, demonstration and others.

The result on farmers' participation in different extension events in relation to conservation tillage technology indicates that only 35.4% of sampled farmers have attended field visit on conservation tillage technology and majority of the farmers (64.6%) did not attend in field visit (Appendix 6). Training is also an important aspect of participation. It equips farmers with new knowledge and skill, which help them to perform new practice properly. If a farmer has no skill and know-how about certain technology, he may have less probability of adoption. The skill acquired through training helps to carry out a new technology effectively and efficiently.

If farmers are well trained in new practice, he may not need outside support later. He himself can properly implement the recommendation. According to the finding, high proportion of adopters (47.9%) and only 15.3% of non-adopters have attended agricultural training (Appendix 6). Out of the total sample respondents, 66.9% did not have chance of training. Similarly, the difference was statistically tested and it was found to be significant at less than 1% level of significance (Table 17). Concerning farmers' presence at training programs, out of total respondent farmers only 33.1 % of them were found to have attended and the rest 66.9 % did not attend in the program.

Table 17 shows that the frequency of participation in field day of adopters was .68 with standard deviation of 3.43 and for non-adopters .17 with standard deviation of 1.76, and frequency of participation in training of adopters was .66 with standard deviation of 1.09. The independent sample t-test showed that there was significant mean difference (t=-6.56, p=0.000,t=-2.42,p=.003) between adopters and non-adopters in relation to frequency of participation in field day and training respectively.

The result of this study is in agreement with the findings of many authors. For instance, Tesfaye and Alemu (2001) reported that attendance of farmers in on-farm demonstration and training contributed positively to farmers' adoption decision. In the same line Yishak (2005), Rahmeto (2007) and Taha (2007) also reported attending extension events were positive and significant relation with adoption of new technologies.

Table 17. Association between communication/extension variables with adoption (n=130)

Variables		Adopter category		t	p
		Adopter	Non-adopter		
Field day	Mean	.68	.17		
	SD	3.43	1.76	-6.56	.000***
Training	Mean	.66	.24		
	SD	2.87	1.09	-2.42	.003***
Frequency of ext.con	Mean	2.44	.966		
	SD	1.41	1.085	5.64	.000***
Frequency of mass media	Mean	4.42	4.13		
	SD	3.56	3.11	.483	.630^{ns}

Source own survey data, 2010. ***Significant at less than 1% level,ns=non-significant.

Farmers' perception on conservation tillage technology

The relative superiority of the technology in terms of its advantage will enable farmers to have favorable perception about the technology, which enhances decision in favor of adoption of the technology. Farmers' perception about technology is one of the factors, which can facilitate or undermine adoption of conservation tillage technology. Farmers were asked to respond how they perceive conservation tillage technology over traditional one.

Both adopters and non-adopters equally prefer conservation tillage technology over traditional one for its reducing labor cost in weeding and oxen rent, increasing yield, conserving soil moisture and easy to plow. All farmers in both groups were very interested to use the technology if the condition especially the weather allow them rather than using conventional one and sowing without herbicide.

During group discussion farmers reported that, lack of affordable mini-packs of herbicide is the main constraint, which is packed in 5 liters.They are conscious and well informed about the technology. However, as already mentioned, different socio-economic and institutional factors hinder them from using the technology. The distribution of respondents on perception of the technology is discussed in Table 18.

Table 18. Distribution of respondents on perception (%)

List of advantages	Less important	Important	Highly important	Mean	SD
In increasing income	.8	32.3	59.2	3.23	.985
In increasing yield	.8	36.2	50	3.12	.940

Source own survey data, 2010.

With regard to the assessment of perception, an index which identifies how well certain attributes of conservation tillage technology meet farmers' preference over the traditional one of a four point scale was used. Accordingly, the rating was (1) less important, (2) important, (3) more important, (4) highly important and they were used to measure the respondents' perception to the technology. The larger value (4) indicates that farmers perceived the characteristics being presented for evaluation as being embodied with the technology and values of 3, 2 and 1 with their respective importance in a decreasing manner. In the list of advantages, a value less than two indicates how the farmer perceives the characteristics under evaluation as poor or negative and in the list of disadvantages the reverse is true.

As Table 19 clearly indicates farmers' response on why they prefer conservation tillage from traditional one. About 55% sampled households mentioned saving labor cost, 14% of them pointed out cheaper, 5% easy to apply and 21% all reasons mentioned above .Some of the farmers perceive CT technology negatively because of price of herbicide increment from year to year and it's poisonous to animals and human beings. About 37% of adopters and 44% of non

adopters put high price of herbicide as its weak side; while about 13% of adopters and 5% of non-adopters emphasized danger for grazing animals.

Table 19. Reasons for preferring conservation tillage from traditional one

Reasons for preference	Adopters		Non adopters		Total	
	N	%	N	%	N	%
Advantages						
Lower cost	13	18.3	5	8.5	18	13.8
Easy to apply	5	7.0	2	3.4	7	5.4
Saving labor	37	52.1	35	59.3	72	55.4
All	13	18.3	14	23.7	27	20.8
Disadvantages						
Not concerned	24	33.8	16	27.1	40	30.8
High cost	26	36.6	26	44.1	52	40.0
Danger in handling poisonous	5	7.0	1	1.7	6	4.6
Danger for grazing animals	9	12.7	3	5.1	12	9.2
Pollution to environment	5	7.0	2	3.4	7	5.4
Others	2	2.8	11	18.6	13	10

Source own survey data, 2010.

Total perception of the technology (PERCT)

Total perception score for relative advantages of CT technology for whole respondents was 1329. This number was divided by 130 to get the average total score for a household head in the sample and it was found to be 10.22,which is a bit similar with the median score (11.00), implying slightly positive perception towards technology package, i.e., in increasing income and yield. This figure masks the very negative perception farmers have towards CT technology.

Hence care should be taken so as not to forget or misguided by this figure, which is the result of high influence of herbicides' relative advantage ratings of the respondents.

In order to summarize the discussion on perception of sample households and to examine its influence on adoption of the overall technologies, it was important to calculate the total perception score of the technologies with regard to the relative advantages and disadvantages of CT technologies. Efforts were made to see the association between adoption of CT technologies and farmers' perception on relative advantages of technology attributes.

Table 20. Association between Socio-psychological variables with adoption (n=130)

Variables		Adopter category		t	P
		Adopter	Non adopter		
Total perception on CT technology	Mean	10.30	10.11		
	SD	1.83	1.88	-.585	.560^{ns}
Social participation	Mean	12.54	6.72		
	SD	8.72	8.45	-.3.841	.001***
Cosmopoliteness	Mean	5.29	5.37		
	SD	2.24	1.91	.208	.836 ^{ns}
Information seeking behavior	Mean	6.15	5.63		
	SD	6.79	6.54	.442	.659^{ns}

Source own survey data, 2010.significant at 1%,ns=non-significant.

In table 20 the t-test result shows the absence of significant mean difference (t=-.585,p=.560) between adopters and non-adopters in relation to perceived relative advantages and disadvantages of the technology. This might indicate that all respondents have relatively similar awareness level and perception on the positive attributes of the CT technologies.

Participation in social organization (PARISOC)

Participation in social organization is expected to have an indirect influence on the adoption behavior of farmers. It links the individual to the larger society and exposes him to a variety of ideas. This exposure makes him positively predisposed towards innovative ideas and practices. The social participation scores of the farmers were calculated on the basis of scores given for their membership status, score of zero was given for non participant, score of 1 was given for those who are members only, 2 was given for those who are committee members, and score of 3 was given for those who are leaders of organization. To see each farmer's level of social participation in local organizations, 9 organizations were included in the interview schedule. A farmer's maximum total score to achieve accordingly was 27.

Table 20 indicates that the average score for sample households was 9.9. While the mean score of social participation for non adopters was 6.72 and for adopters12.54. The results of t-test (t=-.3.841 and P=0.001) reveals statistically significant mean difference between adopters and non-adopter in relation to social participation score at 1% probability level. This result reaffirms previous findings of Dereje (2006), Ebrahim (2006), Rahmeto (2007) and Almaz (2008).

Cosmopoliteness (COSMO)

Farmers' exposure to outside social system was hypothesized to affect adoption of CT technologies. In other words, it was assumed to influence access to information on improved farming practices as compared to the other members of the group.

The survey result on the variable in Table 20 summarized that the frequency of the household to outside and the purpose of visit between adopters and non adopters shows average score of 5.29% and 5.37% for adopters and non adopters, respectively. The t-test value indicates that cosmopoliteness, had insignificant relationship (t=.208, p=0.836) with adoption of conservation tillage technology (Table 20). The probable reason might be the visits to urban or out of the community were not related to agricultural subjects, rather marketing and visit to relatives. The

result of this study was consistent with the findings of Asres (2005) and Almaz(2008).

Information seeking behavior (INSEK)

Information seeking behavior is the degree to which the respondent is eager to get information from various sources on different roles she/he performs. As presented in Table 20, the t-test showed that, there was no significant difference between adopters and non-adopters in CT technology based on their information seeking behavior**.**

4.4. Summary of Results of Descriptive Analysis

Before passing to the econometric part of the analysis it is important to summarize the results of the descriptive statistics. In this study respondents were treated in two categories. The differences between adopters and non-adopters were assessed using t-test and Chi-square test statistics for continuous and dummy/categorized variables, respectively. The mean and SD were used to discriminate the two categories for continuous variables. Out of the hypothesized 18 explanatory variables, 9 of them had shown significant association with adoption of conservation tillage technology. There were also variables in both continuous and dummy/categorized variables which failed to discriminate between adopters and non-adopters. This might be due to the homogeneity of the sample respondents in those factors. Summary of the overall findings is presented in Tables 21 and 22.

Table 21. Summary of continuous explanatory variables (n=130)

Variables	Mean value		t-value
	Adopters	Non-adopters	
AGEHH	44.15	38.51	.001***
FAEXHH	18.76	15.25	.000***
AFLAB	3.07	2.5	.023**
LAHOSZ	10.88	6.0	.010***
TLTLU	8.97	5.29	.011***
FTOEXV	2.44	1.41	.000***
FREOFFIELDPA	.68	.17	.000***
FREOFTRAPA	.66	.24	.003***
SOCIPA	12.54	6.72	.000***
INSEK	6.15	5.63	.442NS
FRMAME	4.42	4.13	.483NS
HERPRI	3.76	3.61	.400NS
PEROTEC	10.3	10.11	.585NS
COSMO	5.29	5.37	.836NS
TOINCOME	2.5246	1.9898	.625NS

Source: own survey, 2010. ***Significant at1%, ** significant at 5% and NS=Non significant

Table 22. Summary of categorized and dummy explanatory variables (N=130)

Variables	Proportion between adopters and non- adopters (%)			χ^2-Value
	Response	Adopters	Non-adopters	
EDUHH	Illiterate	23.8	23.1	
	Only read&write	30.8	22.3	.414 NS
CREDIT	Yes	33.8	74.6	
	No	66.2	25.4	.877 NS

Source: own survey 2010. ***Significant at1%,** significant at 5%,* significant at 10% and NS=Non significant

4.6. Results of the Econometric Model

The previous section dealt mainly with description of the sample population and test of the existence of association between the dependent and explanatory variables to identify factors affecting adoption of conservation tillage technology. Identification of these factors alone is, however, not enough unless the relative influence of each factor is known for priority based intervention. In this section, binary logistics econometric model was used to see the relative influence of different personal, demographic, socio-economic, institutional and psychological variables on adoption of conservation tillage technology.

Before running the binary logit model all the hypothesized explanatory variables were checked for the existence of multi-colinearity problem. VIF (variance inflation factor) was used for testing the association between the hypothesized continuous variables .The VIF values displayed in Appendix 3 show that all the continuous explanatory variables have no serious multi-colinearity problem. Similarly, contingency coefficient test were used to acertain the degree of association among dummy variables.

The values of contingency coefficient ranges between 0 and 1, with zero indicating no association between the variables and values close to 1 indicating high degree of association. The association is said to be high when the value is greater than 0.75. The values of the contingency coefficients were also low (Appendix 4).

Finally, all hypothesized explanatory variables were included in the Binary logistic analysis. These variables were selected on the basis of theoretical explanations, personal observations and the results of the survey studies. To determine the best subset of explanatory variables that are good predictors of the dependent variable, the logistic regressions were estimated using the method of maximum likelihood estimation, which is available in statistical software program (SPSS version 16). All the above-mentioned variables were entered in a single step.

The logit model results used to study factors influencing the adoption decision of conservation tillage technology are shown in Table 23. The various goodness of fit measures state that the model fits that data well. The likelihood ratio test statistics exceed the chi-square critical values with 17 degree of freedom at less than 1% probability levels indicating that the hypothesis that all the coefficients, except the intercept are equal to zero is rejected. The value of Pearson chi-square test shows the overall goodness of –fit of the model at less than 1% Probability level.

Another measure of goodness of fit is based on a method that classifies the predicted value of the dependent variable, adoption of conservation tillage, as 1 if adopted and 0 otherwise. This classification is the result of cross-classifying the outcome variable, y, with a dichotomous variable whose values are derived from the estimated logistic probabilities. In this approach, estimated probabilities are used to predict group membership. They say that, if the model predicts group membership accurately according to some criteria, then this is thought to provide evidence that the model fits.

The model explained about 86.2% of the total variation in the sample for use of conservation tillage. Correctly predicted figures for adopters were about 88.7%; while correctly predicted sample size for non-adopters were 83.1%. Among the explanatory variables used in the model,

5 variables were significant with respect to adoption of conservation tillage with less than 10% of the probability level. The significant explanatory variables on adoption in study area is discussed below:

Frequency of extension agent contact (FREOFCONT): As expected frequency of extension agent contact positively and significantly influenced the likelihood of adopting conservation tillage. Keeping other variable at their mean level, the odds ratio in favor of adoption increases by 2.865 as frequency of extension contact increases by one unit (one day). Similar results were reported by Bezabih (2000), Abrhaley (2007) and Almaz (2008).

Land holding (TAREA): The result in Table 23 revealed that land holding was positively related with adoption of conservation tillage technology at less than 5% significance level. According to the model result, households land holding accounted 16.4 % of the variation in adoption of conservation tillage technology. This is in line with the hypothesis that households who had large land are more likely to adopt new technology. On the contrary, farmers who had small land face out difficulty to adopt and increase level of use. This suggests the need to support farmers who had small land to enhance the adoption process. The result of this study is congruent with the findings of Yishak (2005), Dereje (2006) and Almaz (2008).

Social participation (TOTALSOCPAR): Membership and frequency of participation in different social organization is the other important variable expected to have relation with adoption of conservation tillage technology. As was expected, in this study, participation in social organization had positive influence on adoption of conservation tillage technology at less than 5% significant level. As indicated in Table 23, participation in social organization accounted for about 9% of the variation in adoption of conservation tillage technology. This clearly shows the importance of participation in social organization in adoption of new technologies in general, conservation tillage technology in particular. Participation of farmers in social organization would facilitate access to credit, access to extension information and access to market. This implies the need to strengthen rural social organization to enhance

adoption of conservation tillage technology. Dereje (2006) and Almaz (2008) found that social participation positively and significantly influenced the probability of adoption.

Field day participation: attendance in extension events is the other means through which farmers get information about improved technologies. These events include extension arrangements such as training and field visits. In this study, attendance of farmers in field day was considered as one aggregate variable. Result of the finding indicated attendance in field day was positively and significantly related to adoption of conservation tillage technology at 10% significance level.

Farm experience of Household head (FARMEXHH): The binary logit model result indicated that farm experience of household head positively associated with the probability of adoption of conservation tillage technology at less than 1% significant level. The implication is that farmers who have more years of farm experience are more likely to adopt conservation tillage technology than those farmers who have less years of farm experience. This result also goes along with a prior expectation that was experience would improve the farmers' skill in crop production. Farmers with higher experience appear to have often full information and better knowledge and able to evaluate the advantage of the technology. Other things kept the same; the odds ratio of 1.345 for farm experience indicates that, as farm experience increases by one year, the odds ratio in favor of adopting conservation tillage technology increases by a factor of 1.345

Table 23. Binary logit model estimates for factors affecting conservation tillage technology

Variables	Coefficient	S.E.	Wald	Sig.	Odds ratio
Constant	-6.763	3.231	4.381	.036**	.001
AGEHH	-.047	.049	.927	.336	.954
FARMEXHH	.296	.076	15.121	00***	1.345
EDUCHH	.292	.685	.181	.670	1.339
TAREA	.164	.068	5.828	.016**	1.178
HERBICIDEPRI	-.433	.395	1.206	.272	.648
CREDIT	-.388	.970	.160	.689	.679
FREOFCON	1.052	.323	10.639	.001***	2.865
FREOFFILDPA	.946	.554	2.916	.088*	2.575
FREOFTRAPA	.602	.411	2.148	.143	1.825
AFLF	-.178	.303	.346	.556	.837
LIVSTLU	.006	.050	.014	.907	1.006
PEROTEC	.111	.213	.273	.601	1.118
TOTALSOCPAR	.090	.041	4.912	.027**	1.094
COSMOPOL	.173	.165	1.108	.292	1.189
INFSEBEH	-.012	.050	.055	.814	.988
FROMAME	-.130	.114	1.301	.254	.879
TOINCOME	.000	.000	.131	.718	1.000

-2 Log likelihood ratio=78.343

Chi-square value=100.766***

Correctly predicted over all sample=86.2

Correctly predicted adopters=88.7

Correctly predicted non-adopters=83.1

Source: model output. ***Significant at1%,** significant at 5% and* significant at 10%.

Reason for Discontinuing Use of Conservation Tillage

A decision to discontinue a practice is either to cease using an idea in order to adopt a better idea, which supersedes it or to cease using an idea as a result of dissatisfaction with its performance (Rogers, 1983, and Ray, 2001). Francis and Branan (1987) also mentioned that the most fundamental has been the favorable price being offered for the variety, that is, if the price declines for the variety farmers may discontinue. The other most important factors for sustainable use of technologies are the supply of herbicides. For instance, Chambers *et al*. (1989) stated that a productive agriculture requires a constantly changing mix of techniques and inputs. Seeds degenerate, insect pests spread and develop resistance to pesticides, market prices fluctuate, new inputs appear and old ones become expensive, agricultural and trading laws change.

In this study the result obtained was similar to the view of Rogers (1983), Francis and Branan (1987) and Ray (2001). In this study 28 sample respondents were dis-adopters (discontinuers) During focused group discussion discontinuers explained some reasons for discontinuance. These include the cost of herbicide increase from time to time, first it was 75 birr/liter and now it reached 138.2 birr/liter and there was no credit supply to purchase the herbicide. The second was the quantity of the herbicide supplied this year was sealed with 5 liters. It was difficult to purchase and use since its price was expensive for a single household and to collect and to distribute in to 5 was a tedious work. Farmers need a herbicide with the amount of 1 liter. The quality of the herbicide was also another factor for discontinuity. In the previous cropping season the herbicide was effective for all weed species (broad leaf and grassy), but last year (2008/9), it was effective only for grassy weeds. This indicates that the quality deteriorates from year to year, without knowing its shelf life, farmers also use out of dated products. In order to tackle this problem farmers mix 2-4D which is broad leaf herbicide with Round –up (1/3 2-4Dwith 2/3 Round-up).

The other factor was the supply of herbicide was not on time, especially during the first ploughing season of the study area (in April and may).there was also a big problem of supplier to get where ever required. In general, increment of herbicide price, lack of affordable mini-packs (with 1 or 2 litres pack), quality deterioration, and unavailability of the herbicide on time and shortage of supplier were some of the reasons for discontinuance and lack of affordable mini-pack being the main among them.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary and Conclusion

This study was conducted in Metema Woreda, which is located in North West part of Ethiopia 180 km. from Gondar town. In the study area farmers are suffering from the crop loss caused by weeds, which consequently, forced them to pay high cost for instance, for hand weeding and renting oxen for ploughing. In an attempt to reduce some of these problems, non-governmental organizations such as IPMS initiated new weed control practice in Metema in 2005. As a result, demonstration was prepared, training was given to woreda experts, development agents and farmers, organized field days in different PAs, and input suppliers were formed. Nevertheless, at the same year (2005) only six PAs started using the technology. Later on the demand for the herbicide arose in other neighboring kebele farmers. By now (i.e 2010) the spread of this technology continued within and out of the Metema woreda.

Thus, selecting Metema woreda as its setting the specific intents of this study were (1) to assess the rate of adoption of conservation tillage technology by farmers ;(2) to explore the contribution of farmer-to-farmer knowledge/material sharing for adoption and diffusion; and (3) to determine the factors influencing adoption of conservation tillage technologies.

Multistage sampling procedure was used to select the sample PAs and household farmers. First, purposively North Gondar zone, Metema woreda was sampled because it is one of the intervention woreda. Then, PAs were stratified in to two according to exposure of the technology. The selected PAs were further stratified into two based on distance to the woreda capital. Then, two PAs form early exposed and two PAs from the late exposed groups were selected randomly (one from far and one from near woreda capital in each stratum) among the total 18 PAs. Sample farmers were selected using simple random sampling technique. Finally, random sample of 130 farmers were drawn from the selected PAs by applying PPs. The data included both qualitative and quantitative research design. Structured interview schedule was

used to collect the essential data from the respondents. To generate qualitative data on the one hand informal discussion with key informants and on the other, group discussion with separate groups (in each kebele), responsible DAs and woreda officials were conducted.

Different analytical techniques were applied to analyze the collected data. Percentage and frequencies were used to assess the rate of adoption of CT and to explore the contribution of farmer-to-farmer knowledge/material (improved technology) sharing for more adoption and diffusion. Descriptive statistics such as mean, standard deviation, t-test and chi-square were employed to make a comparative analysis of the independent variables and farmers' adoption of CT technology. Binary logit model was employed to identify the various factors influencing adoption of the technology.

Variation in adoption among the sample households was assessed in view of various factors that are theoretically known to influence farmers' adoption behavior of new technologies. These variables were categorized as personal and demographic, economic, socio-psychological, and communication/extension variables. Result of descriptive statistics using t-test and chi-square indicated that some of the variables hypothesized to influence farmers' adoption behavior were significantly related with adoption of CT technology. Moreover, contingency coefficient tests and VIF (variance inflation factor) also indicated that the direction and strength of association between the hypothesized continuous and dummy/categorized explanatory variables with adoption of CT technology.

The knowledge network analysis in this study confirmed that the main sources of new knowledge for sample farmers were, friends, neighbors and development agents in their social system. The analysis showed that experience sharing at work, interpersonal communication and during- market- day discussions, (rather than receiving from external organizations) were the mechanisms through which knowledge /information are shared.

Based on the descriptive statistics, household's personal and demographic factors, age and farming experience of the household head were found to be significantly related to adoption of CT technology. The data indicated that older farmers may have already developed better

experience that face exposure opportunities with using large size of improved agricultural technologies through their life experience. These might be the reason why how to manage risks and taking of the first benefits from new technologies are positively correlated with adoption.

The data analysis also showed that, household economic related variables are the other important factors which influence adoption of conservation tillage technology. Total land holding, livestock holding and active family labor force were found to have positive and significant relationship with adoption. Adopter groups have relatively larger land size and livestock and more labor force compared to the non-adopters.

With regard to the household's socio-psychological variables, adopter groups have relatively better participation in social organization as compared to non-adopter groups. These indicate that social participation was found to be positively and significantly related with adoption of CT technology.

The data confirmed that, concerning communication/extension variables, adopter groups have relatively high frequency of contact with extension agent. In addition, participation in extension events was higher in adopters compared to non- adopters. These indicate that frequency of contact with extension agent and participation in extension events found to have positive and significant relationship with adoption of CT technology.

On the other hand, results of the Binary logit model indicated the relative influence of different variables on adoption of CT technology. All hypothesized explanatory variables were included in the model of which five (5) of them had shown significant influence on adoption of conservation tillage technology. Accordingly, farming experience of the households, total land holding, social participation, frequency of contact with extension agent and frequency of participation in field days were found to have positive and significant influence on adoption of conservation tillage technology in agreement to the initial hypothesis.

5.2. Recommendations

Development policies and program interventions designed to enhance agricultural productivity through promoting different agricultural technologies in general and conservation tillage technologies in particular. In the study area, there is a need to take into account the aforementioned variables and farmers' perception on the technology. More specifically, based on the empirical findings of this study, the following recommendations are forwarded:

- ❖ Conservation tillage farming involves different practices which require knowledge, skill and management. This research finding indicated that farmers generate knowledge continuously and shared among them. In this regard, they were not well supported and integrated with external organizations. Therefore, researchers and extension staff need to continuously keep in touch with these farmers for further research to address issues that need to be resolved.

- ❖ It was found that total land holding significantly affects adoption of conservation tillage technology. The result shows that the new tillage technology is more likely to be adopted by farmers with large land size suggesting research, extension and planning agencies to be sensitive to the needs of smallholder farmers through developing and disseminating technologies and strategies that are relevant to their needs.

- ❖ Results of this study also indicated that there was significant difference in adoption and level of adoption among farmers with high and low participation in social organizations. On the other hand, farmers who were member of social organizations and frequency of participation were found to obtain better extension services, production inputs, credit, and other services. Hence, this calls for establishment, encouragement and strengthening of social organizations to enhance adoption of conservation tillage technology.

- In the same manner, frequency of contact with extension agents has positively and significantly influenced adoption of conservation tillage technologies suggesting the need for more targeted and continued extension services. Thus, the extension system operating in the areas and elsewhere, need to be strengthened further to increase the flow of information for rural development. Participatory community based approaches involving the stakeholders in planning and implementation are necessary in order to create a higher ownership attitude. Clear messages on conservation tillage should be included in the normal extension packages and training of both village extension workers and farmers should be emphasized so as to improve their understanding and skills.

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Generally, it is worth noting that adopters as well as non adopters have indifferent perception on the positive and negative aspect of CT, but other factors have more influence on adoption decision. Suggesting that other unconsidered factors such as yield and profitability might explain observed differential adoption. Further research on relative advantage of CT over conventional tillage, changes in yield increase, appropriate soil type for the technology, impact of the technology in the environment and its effect on pasture and grazing land is very essential.

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7. APPENDICES

LIST OF TABLES IN THE APPENDIX

7.1 APPENDIX

Appendix table 1.Conversion factor used to compute man equivalent (Labor Force)

Age group (years)	Male	Female
Less than 10	0.0	0.0
10-13	0.2	0.2
14-16	0.5	0.4
17-50	1.0	0.8
Greater than 50	0.7	0.5

Source: Stork, *et al.*, 1991.

Appendix table 2.Conversion factors used to estimate tropical livestock unit

Animal Category	TTLU	Animal Category	TTLU
Calf	0.25	Donkey (young)	0.35
Weaned Calf	0.34	Camel	1.25
Heifer	0.75	Sheep & Goats (adult)	0.13
Cow and Ox	1.00	Sheep & Goats (young)	0.06
Horse	1.10	Chicken	0.013
Donkey (adult)	0.70		

Source: Stork, *et al.*, 1991.

Appendix table 3.Variance Inflation Factors (VIF) of the continuous variables

VARIABLE	**Tolerance**	**VIF**
AGEHH	.457	2.188
FARMEXHH	.486	2.059
TAREA	.513	1.950
FREOFCON	.787	1.270
HERBICIDEPRI	.714	1.400
FREOFFILDPA	.694	1.442
FREOFTRAPA	.711	1.407
AFLF	.648	1.542
LIVSTLU	.462	2.166
PEROTEC	.718	1.394
TOTALSOCPAR	.749	1.335
COSMOPOL	.752	1.330
FREMAME	.730	1.370
TOINCOME	.834	1.199
INFSEBEH	.812	1.232

Appendix table 4. Contingency coefficient of dummy/categorized variables

VARIABLES	EDUHH	HERBICIDEAVA
EDUHH	1	.048
HERBICIDEAVA	.048	1

Source, model result.2010.

Appendix table5. Distribution of sample respondents by off farm activities(n=130)

Off-farm/Non-farm activity engagement	Adopters		Non-adopters		Total	
	N	%	N	%	N	%
Yes	11	15.5	9	15.3	20	15.4
No	60	84.5	50	84.7	110	84.6
Total	71	100	59	100	130	100

Source, model result.2010.

Appendix table 6. Farmers' participation in different extension events(n=130)

Responses	Extension events			
	Field visit		Training	
	N	%	N	%
Yes	46	35.4	43	33.1
No	84	64.6	87	66.9
Total	130	100	130	100

Source, model result.2010.

7.2 APPENDIX II

Interview schedule

Haramaya University, School of Graduate Studies,

Farmer Number _____ Date (dd/mm/yr): _____/ _____/ _____

Region _____	Zone _____
Farmer's Name_____	Woreda _____
Peasant association (PA): _____	Village (Gotte): _____
Enumerator's name	Signature _____

1st check by _____ Date_____/_____/_____ initial _____

Part 1: Household Characteristics

11 Household characteristics

ID Code	Name of Family member	Sex Male=1 Female=0	Relation to the head of HH	Age (years)	Education level	Major Occupation
1						
2						
3						
4						
5						
6						

Relation to HH head: 1=wife, 2=child, 3=grand child, 4=brother, 6=sister, 7=hired labor, 7=other

Education status: 0=illiterate, 1=Read and Write, 2=4-9 grade and 3=above grade 10

Major occupation: 1=dependent, 2=student (at school), 3=house wife, 4=farming, 5=hired labor, 6=off farm activity, 7= other, specify

1.2 Type of house the household owns

	Yes/No	Number owned
Grass roofed		
Corrugated		

1.3 Farming experience of household head ---------- (in years)

1.4. Land holdings, tenure status and plot characteristics (all plots including own cultivated, rented in or given out in any form should be included)

Plot Number	Area (Timad/Kert/Gemed/ha)	Walking Distance from home (minutes/hr/km)	Tenure status (A)	If leased in/out, arrangement (B)	Soil type	Soil fertility status (C)
1						
2						
3						
4						
5						

*Tenure status (A): 1= Own plot (received from PA) 2= leased in, 3=leased out, 4= Gift

*Specific lease arrangement (B): 1=cash (amount/plot), 2= share cropped-equal, 3=share cropped (1/3 to plot owner), 4=share cropped (1/4 to plot owner), 4=other (specify)

*Soil fertility status (C): 4=highly manured (*kossi/areda*),3= very fertile (*lem/woferam*), 2=moderately fertile (*mekakalegna*), 1=infertile/*teaf*

2. Crops grown and cultural practices used during the 2009/10 G.C (2001/2002 E.C)

Plot No	Area (ha)	Crops grown	Variety Used 1=improved 2=local	Land Preparation Method and Frequency		Used Herbicide		Hand Weeding	Production (kg/Quintal
				Method of plowing 1= Pair of oxen 2= Tractor 3= Other	Frequency	1=Yes 2=No	Amount (lt/local unit)	1=Yes 2=No	
1									
2									
3									
4									
5									

2.1 What did you use to plow your fields?

1= Own oxen 2= own tractor 3= rented oxen 4= rented tractor

5=support from relatives 6=others specify

2.2 If accomplished through hire of oxen, what is the cost of a pair of oxen per day_____?

2.3 If accomplished through hire of tractor, what is the cost of tractor per hour_____?

Part 3: Livestock Ownership

Livestock Category	Local (number)	Improved (number)
Cows		
Oxen		
Heifers		
Calves		
Bulls		
Others		
Goats		
Sheep		
Poultry		
Donkey		
Horse		
Others		

Part 4: Family Labor

4.1 Do you have enough labor for accomplishing farming activities on time?

1=Yes 0=No

4.2 If the answer is no, which activities are most affected by labor shortage?

1= land preparation (Plowing) 2= Planting (sowing) 3= Weeding 4= Harvesting

5= in all times 6= in planting and harvesting 7=others (specify)

4.3 How do you overcome the labor shortage constraint?

1= hire labor 2= use labor sharing mechanisms such as debo

3= hire tractor 4= use herbicides 5=hire combiner 6= both 1 and 2

7= other (specify)

4.4 Is labor available for hire easily if you want to do so?

1=Yes 0=No

4.5 In which of the farming activities female family members participate?

1= land preparation (Plowing) 2= Planting (sowing) 3= Weeding

4= Harvesting 5= others (specify) 6=garden work

Part 5: Herbicide Price

5.1 Is herbicide available in time and the right quantity?

1=Yes 0=No

5.2 In your view how do you see the price of non- selective herbicide in relation to hired labor for weeding and plowing?

1=Very expensive 2= expensive 3= moderately expensive 4= less expensive 5=not expensive

Part 6: Extension Contact

Do you get advisory services from extension agents?

1=Yes 0=No

6.2 How frequently do the extension agents visit you in regard to CT technology?

1= Once in a year 2= Once in six month 3= Monthly 4=bi-weekly

5= weekly

6.3 During which farm operation extension agent visit you?

1= Land preparation 2=during input provision 3= during sowing 4=during herbicide application 5= during credit collection 6= 2and4 7= others (Specify)

6.4 Do you visit extension agent?

1=Yes 0=No

6.5 If yes, when do you visit?

1= during planting (sowing) for technical advice 2= during input distribution to obtain input 3= It depends (any time when there is technical problem)

6.6 Have you heard about conservation tillage technology?

1=Yes 0=No

6.7 From who/, which source?

1=MOA 2= DA 3= IPMS= 4= others (specify)

6.8 What is the length of time since you first heard about CT technology _____

6.9 For how many years have you practiced CT technology in your farm? _____

6.10. Have you ever participated in field days/visits prepared on CT technology practices in the last five years? 1=Yes 0=No

6.11 If yes, how many times and who arranged for you? No of times----------

6.12 Who arranged for you?

1= WoARD 2=IPMS 3= NGO 4= Others (Specify) ----------

6.13 Have you ever received training in conservation tillage technology in the last five years?

1=Yes 0=No

6.14 If yes, how many times and who arranged for you? No of times----------

6.15 Who arranged for you?

1= WoARD 2=IPMS 3= NGO 4= Others (Specify) ----------

6.16 Indicate your access to and frequency of use of the following media?

Mass media	How often you use them			
	Always=3	Sometimes=2	Rarely =1	Never=0
Radio				
Television				
Leaflets				
Pamphlets				
Manuals				

Part 7: Utilization of Credit

7.1 Were you demanding for credit in the last 12 months? 1=Yes 0=No

7.2 Did you take any credit for purchasing non-selective herbicides during the last 12months? 1=Yes 0=No

7.3 If yes, from which sources did you borrow?

1= WoRDA 2= co-operatives 3= NGOs 4= private money lenders

5= others (specify)

Part 8: Participation in off-farm and non-farm activities

8.1. Household's participation in off-farm activities in last one year.

1=Yes 0=No

8.2. Household's participation in non-farm activities in last one year.

1=Yes 0=No

8.3 Household's participation in off-farm\non-farm activities in last one year.

No	Name of Participant	Type of activity (A)	Participation time (B)	Participation in a year (C)	Income per day or year

Kind of activities (A): 1= Trading 2= Handicraft 3=Daily laborer 4=others (specify)

Participation time (B): 1=out of the time of farming activities 2=at any time

3= throughout the year 4= others (specify). ----------

Approximate Participation in a year (C) =1 for a month 2=for two months 3=for three months 4=others (specify). ----------

Part 9: Knowledge sharing among farmers

9.1 Did you learn from other farmers? Yes = 1 N0 = 0

If yes, sources of knowledge

No	Source of knowledge	Quantity		
		Most practices 2	Some practices 1	Never 0
1	Development agents			
2	Neighbors			
3	Friends			
4	Wereda Ag. office			
5	IPMS			
6	Radio			
7	Pamphlet			
8	Farmers groups			
9	Relatives			
10	Informal social groups			

9.2 frequency of your knowledge sharing

No	Source of knowledge	Frequency		
		Frequently 2	Sometimes 1	Never = 0
1	Development agents			
2	Neighbors			
3	Friends			
4	Wereda Ag. Office			
5	IPMS			
6	Radio			
7	Pamphlet			
8	Farmers group			
9	Relatives			
10	Informal social groups			

9.3 Do you share your knowledge to other farmers? Yes = 1 No = 0

9.3.1 If yes, for whom you share your knowledge?

No	Knowledge shared	Mostly = 2	Sometimes 1	Never 0
1	Friends			
2	Neighbors			
3	Adjacent farmers			
4	Relatives			
5	Farmer group members			

When do you share your knowledge to others?

No.	Time	Mostly 2	Sometimes 1	Never 0
1	During group discussion			
2	During cooperative assembling			
3	At practical work			
4	At demonstration day			
5	Interpersonal communication			
6	Market day			

If you don't share, why? .....

Knowledge items with their frequency of sharing

No.	knowledge item	sharing with others		frequency of sharing		
		yes	No	in all farming interaction=3	whenever asked =2	only some times =1
1	Spraying of herbicide based on recommendations					
2	Quantity of herbicide used					
3	Quality of herbicide					
4	Time of spray					

Which knowledge was needed by you?

No	Knowledge type	Please sign (X)	Not obtained	Obtained
1	Spraying			
2	Amount usage			
3	Quality identification			
4	Time of spray			

Part 10: Social participation

10.1 Are you involved in formal and informal Organizations in your area?

1= Yes 0= No

10.2 If yes, type of Organizations & responsibility

No	Organization	Measure score	Frequency of participation (C)
1	Farmers multipurpose cooperative /union (A)		
2	Peasant association (A)		
3	Marketing cooperative(A)		
4	Irrigation water committee(A)		
5	Credit committee(A)		
6	Kebele cabinet(A)		
7	Informal association (Idir, equb, mahber, debo) (A)		
8	Religious organization (B)		
9	Any other (specify) (B)		

Measure score (A): Leader = 3, Office bearer/committee=2, Member only =1

Measure score (B): Leader =2, Member only =1

Frequency of participation (C): 0=never, 1=some times, 2=when ever conducted

Part 11: Psychological factors

11.1 Perception about conservation tillage technology /PERCTT/

11.1.1 What is your thinking about conservation tillage technology in terms of increasing your income?

1= less important, 2=important, 3=more important, 4=highly important

11.1.2 What do you think about conservation tillage technology in terms of increasing yield?

1= less important, 2=important, 3=more important, 4=highly important

11.1.3 In your opinion, is it worth buying non-selective herbicide than hand weeding?

2= Yes 1= No

11.1.4 How do you see conservation tillage technology when compared with conventional tillage?

2= Good 1= Bad

11.1.5 If good, why you prefer CT over the conventional one?

1=It is cheaper 2= Easy to apply 3= saving labor 4= others (specify)

11.1.6 If bad, what is the reasons?_____

11.1.7 What is the weak side you observed from CT technology?_____

1= High cost of the chemical 2= Danger in handling poisonous 3= Danger for grazing animals 4= Pollution to environment 5= Any other (specify)

Part 12: Information seeking behavior

12.1.1 Do you need information about conservation tillage technology?

1= Yes 0= No

12.1.2 If yes, amount and frequency of information seeking behavior in the following activities?

No	Information type	Amount of information you wish to get		
		all information =2	1= some information	None= 0
1	Knowledge of applying herbicide			
2	Knowledge of amount of herbicide			
3	About zero tillage			
4	About times of application			

12.1.3 Frequency of information seeking

No	Information type	Frequency information seeking		
		2= frequently	1= Rarely	0= Never
1	Knowledge of applying herbicide			
2	Knowledge of amount of herbicide			
3	About zero tillage			
4	About time of application			

Part 13: Cosmopoliteness

13.1 Do you visit other villages \towns? 1= Yes 0= No

13.2 If yes, How often 1= Rarely 2= Monthly 3= Twice a week

4= Weekly 5= Daily

13.3 For what purpose do you visit the villages \town?

1= for recreation purpose 2= to visit relatives 3= For marketing purpose

4=to purchase agricultural input 5= to discuss on farming issues

13.4 Do you share experience with individuals outside your community? 1= Yes 0=no

7.3 APPENDIX III- Checklist

CHECK LIST FOR FDG

- When this technology came to this village and how?
- Is there any increasing trend?
- Are chemicals available on time when you need it?
- Is it spreading to other crop?
- What are the advantages of this technology?
- What are the disadvantages of this technology?
- What are the constraints faces in using this technology?
- What are the suggestions to overcome this problem?
- What are the expectations from different organizations in relation to this technology?
- Did you share knowledge and skills? When? How?
- What is your benefit gained?
- How is your satisfaction?

Key informants (DAs, wereda officials IPMS and village and cooperative leaders)

- What is your prospect about the technology?
- What is your plan for increasing?
- What are the challenges?
- What is your suggestion to cop up this challenge?
- What are possible strategies to improve the existing problems?